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Reports of fires appearing in the Quarterly are copies of or extracts from written reports forwarded to the Association. This Association, as a body, is not responsible for the statements or opinions of any of its members.

International.

Nine persons lost their lives when an explosion and fire occurred in a gasoline absorption plant at Long Beach, Calif., on June 2, 1933. The explosion wrecked the gasoline plant, surrounding derricks and buildings within a radius of several blocks. Ten crude oil tanks were ignited and the entire vicinity was soon in flames. **(See report on page 141.)**

The Quarterly

Vol. 27 October, 1933 No. 2

Loss of Life by Fire. The prevention of loss of life by fire is the first objective of the Association, as stated in our Articles of Association. We lack any complete statistics of loss of life by fire in the United States, comparable to the statistics of loss of property prepared by the National Board of Fire Underwriters. U. S. Census Bureau mortality statistics do not meet this need, for they include in their fire classifications only a part of the casualties for which fire is responsible. However, efforts to safeguard life from fire are not dependent on complete mortality statistics. The summaries published in the QUARTERLY, showing how the fatalities occur in typical fires, seem of greater practical value as a basis for preventive measures. These summaries have been published in the QUARTERLY for several years, and in this issue there appears a cumulative tabulation giving a detailed analysis of some thirty-five hundred deaths. Accompanying this summary is a computation confirming our previously published total estimate of ten thousand lives lost by fire annually in the United States.

* * * * *

The Los Angeles Park Fire. The loss of twenty-seven lives in a brush fire in a Los Angeles park on October 3 shows again that the life hazard from fire is not limited to buildings, and that the most shocking fire tragedies may occur under conditions not popularly regarded as dangerous. According to preliminary reports a group of park workers, without experience in fire fighting, were directed to extinguish a brush fire and were trapped by the flames with tragic results. Fire fighting is essentially a dangerous occupation. It is doubly perilous where the men are inexperienced and untrained.

* * * * *

The Tillamook Forest Conflagration. After a period of years in which no timber fires in the United States have extended to conflagration proportions, the Oregon forest fire of August 14 to 25 in Tillamook, Washington, and Yamhill Counties, Oregon, comes as a major disaster, with a loss of timber which acccording to preliminary estimates may reach $25,000,000. Surveys of the damage have not been completed as

this QUARTERLY goes to press, so the complete report cannot be published until the January issue.

In addition to the direct loss of timber, there are very serious indirect losses. According to Mr. Sinclair A. Wilson of the U. S. Forest Service the loss of employment in this particular forest area is equivalent to six years of continuous employment for 14,000 men. The fire reduces the annual tax income of Tillamook county by some $400,000, 43% of its annual income. Including all the indirect losses Mr. Wilson estimates that the general public stands to lose $5 for every $1 of direct loss by owners of timber.

* * * * *

Molasses. During the past summer lightning struck a tank on the property of a large oil company; the vapor above the liquid in the tank exploded, blowing off the top of the tank. The ensuing fire was a stubborn one, spread to an adjoining tank, and despite the efforts of a well-equipped city fire department was not extinguished before the contents of both tanks were destroyed. The public naturally concluded that it was gasoline which had burned, but as a matter of fact it was not any petroleum product, but molasses stored in a tank leased from the oil company.

Molasses is popularly considered a harmless liquid, although Boston still remembers the molasses tank disaster of 1919 in which some twenty persons were killed. Molasses ferments to form alcohol, and it was doubtless a mixture of alcohol vapor and air which exploded to start the fire referred to in the preceding paragraph. Molasses should not be placed in the same fire hazard class as gasoline, but like many other ordinarily harmless substances, under certain combinations of circumstances it does present a very definite hazard, which may be more serious because not realized.

The Westwego, La., alcohol fire described in this issue presents another example of large scale molasses storage. In the Westwego case, the fire started in a molasses tank which had been converted for the storage of alcohol. Several near-by molasses tanks, with combustible roofs, were severely exposed, but only about ten per cent of the four or five million gallons of molasses was lost.

* * * * *

Measurement of Fire. The science of engineering subjects depends for its development very largely upon the use of standard units of measurement. Basic units of intensity, quantity and time form the essential background of experiments and technical discussions in almost any engineering field.

Fire protection engineers regard fire control as a scientific subject comparable with other branches of engineering. They are handicapped, how-

ever, by the lack of any complete standard for the measurement of fire. The intensity factor is recorded in temperature readings, which when combined with the time factor form the basis of the standard time temperature curve, which has been of great value in the development of the science of fire protection. There is, however, no standard unit or even a common language to describe the quantity of fire. The terms "incipient," "small," and "large" are used by fire protection engineers without any common understanding as to size of fire described. Discussions between fire protection engineers are often handicapped, for example, by varying conceptions of the size of an incipient fire which fire protection equipment is being designed to control.

There seems to be a definite need for some established unit of measurement of size of fire. The temperature and time factors, while important, are not of themselves sufficient for the purpose. Quantity of heat, perhaps expressed in British thermal units per minute, might be a useful unit of measurement, but is open to various practical objections. The answer to this problem is not obvious, but it seems clear that until some unit of measurement of quantity of fire can be established the science of fire protection will be definitely at a handicap as compared with other engineering sciences.

* * * * *

Legal Work in the Fire Department. Duties of fire departments are daily becoming more and more complex. The need of technically trained men to handle certain phases of the department work has already been recognized. An interesting example of a function not commonly thought of in connection with fire departments is the legal aspects of the work of some of the more progressive large city fire departments. For example, the head of the legal department of the Los Angeles Fire Department in outlining his functions and duties at the request of Chief Ralph J. Scott listed the following.

1. To prepare drafts of new ordinances and amendments to existing ordinances which come under the jurisdiction of the fire department. In this the legal department acts as associate counsel with the city attorney, making sure that the ordinances which come officially from the city attorney's office are drawn to the satisfaction of the fire department.

2. To make out complaints to the city prosecutor's office for reported violations of all ordinances enforced by the fire department and file the same with the clerk of the Municipal Court.

3. To make investigations of violations and interview parties concerned to secure, if possible, abatement of violations without recourse to the courts.

4. To act as associate counsel to the city prosecutor in the prosecution of misdemeanor cases, involving violations of fire ordinances to the end that the courts may have a better understanding of the seriousness of the fire hazard

from the fire department viewpoint and the better to enable the courts to inflict a penalty appropriate to the offense committed.

5. To represent the chief engineer in special investigations involving any local matter affecting the fire department.

6. To act as legal adviser to the bureau of fire prevention in matters such as inspection work.

7. To act as legal adviser to the bureau of fire investigation in matters relating to evidence and similar matters.

Sprinkler Users Win Rate Case.

Missouri Public Service Commission Reverses Its Former Position in Important Decision on Private Fire Service Charges.

On August 25, 1933 the Missouri Public Service Commission handed down a decision of far reaching importance on private fire service charges. Not only did the commission declare that their previous position sustaining high private fire service charges was in error, but they attacked the numerically large weight of commission and judicial authority which has supported high private fire service charges in a few jurisdictions.

The case was No. 6851 in the matter of the application of the City of St. Joseph for an order requiring the St. Joseph Water Company to reduce its rates to its consumers, and for an order directing a revaluation of the property of the St. Joseph Water Company. The owners of automatic sprinkler installations organized and appeared in the case as intervenors to ask for a review of the following schedule of charges in force for private fire services.

$60 per year minimum, which entitles owner to 1,000 sprinkler heads
6c each per year for all over 1,000 sprinkler heads.
$48 per year for each private fire hydrant.
$7.50 per year for each 1¼-inch standpipe hose connection.
$20 per year for each 2½-inch standpipe hose connection.

The size of the connection to the main has no bearing on the above rates.

Counsel for the sprinkler users was Stringfellow and Garvey, law firm of St. Joseph. The N.F.P.A. Executive Office has been following the case closely during the last year, and with other interested members assisted the counsel in assembling the necessary information and data on which the contentions of the sprinkler users were based. A brief prepared by Attorney Stringfellow for the sprinkler users' case was drawn with particular skill and made good use of the reasoning followed in the report of the N.F.P.A. Committee on Public Water Supplies for Private Fire Protection.

The success of the sprinkler users in this case shows two things very clearly:

(1) The importance of sprinkler users organizing to present their case fully, retaining competent counsel and securing technical assistance.

(2) That previous decisions supporting high private fire service charges are legally in error.

The opinion of the commission in the case so far as it relates to the sprinkler users is given below.

Opinion of the Commission.

The intervenors, users of fire sprinkler service, have directly challenged both the reasonableness of the rates charged for sprinkler service and the propriety of making any charge whatever for this service. Their contention is that the entire cost of fire protection is and should be paid for by the city.

The amount and character of fire protection to be furnished in a municipality is determined by the properly qualified municipal authorities after a survey and study of all conditions as to hazards and related matters. The Board of Fire Underwriters usually participates in the survey and study. The quantity and pressure of water that should be available for sustained periods for fire fighting purposes is determined, also the number, locations and spacing of fire plugs, and also the personnel of the fire fighting department, and its equipment and apparatus, in the nature of stations, trucks, engines, hose and the like.

The city assumes the obligation of furnishing fire protection to its inhabitants. It contracts with the water company for a supply of water to be available in the quantities and for the periods necessary, and for the necessary fire plugs, and organizes, equips and maintains its fire department. And to defray the cost of all of this, it levies taxes upon its inhabitants.

As far as the water company is concerned, it provides the necessary plant and facilities so as to have water available in the quantities and at the pressure necessary, and the necessary fire plugs, ordered by the city. It makes a charge against the city which for convenience is based upon an annual rental for each fire plug. This charge is to reimburse the company for the cost of providing, maintaining and operating the facilities which it provides for fire protection service, and also includes a charge for the quantities of water that are supplied through the fire plugs. This charge, of course, after payment by the city is passed on to the general public through the taxes levied by the city to maintain fire protection.

The sprinkler user, as a member of the community, pays his municipal taxes and is entitled to the fire protection provided by the city. But he has installed apparatus upon his own premises for fire protection purposes. He taps the company's mains and installs at his own expense a series of pipes equipped with sprinkler heads, throughout his premises. In case of fire, the sprinkler heads automatically open and discharge water directly to the seat of the fire. This is an efficient system and in most cases will extinguish a fire in its incipiency, thus making it unnecessary for the city to render aid. Indeed it is of further benefit to the city since it reduces the fire hazard for the city at large and improves insurance rates.

The company's witness testified that the sprinkler systems place no demand upon the water company, additional to the demand contracted and paid for by the city.

Let us assume for the sake of clearness that the company has installed entirely separate plant and facilities for fire protection purposes, separate pumps, reservoirs, pipes, hydrants, and appurtenant facilities, all of which is determined by the amount of fire protection necessary. The sprinkler user is entitled to his protection from this system for he has paid his proportion of the cost in taxes. And when he makes use of this property through his sprinkler system, all he does is to bring the water to the seat of the fire automatically, and in less time, and in most cases more efficiently, than it would be brought by the fire department from the hydrants, through the hose. He pays his proportion of the cost of the water plant and of the water, just as does anyone else, through his taxes. The only practical difference between the sprinkler user and an industry not having a sprinkler system, is that the sprinkler user elects to bring the water to the seat of the fire in a quicker and more efficient manner, and to do this he installs his sprinkler system at his own expense. The water and the plant necessary to supply the water is provided for the city at large and is maintained through taxation.

It therefore seems clear that the sprinkler user should not pay to the water company any charges which are based upon the cost of water and the cost of facilities to supply water for general fire protection purposes. The sprinkler user pays for this through his taxes.

There is, however, some additional expense caused by the sprinkler systems. It is necessary for the company periodically to inspect these installations, and in some cases to install meters, to insure that the water be not used for other than fire protection purposes. In some cases, some additional local equipment is installed by the company, and each additional tap in the company's mains creates an additional weakness in the system. The sprinkler user should pay these costs, for they are additional expenses created solely by him.

If the present rates charged for sprinkler service are too high the adjustment thereof should be between the company, the city, and the sprinkler users. The domestic and industrial consumers should not be called upon to pay for such special and additional fire protection service. These customers likewise pay for fire protection through taxation.

On the subject of the reasonableness of the rate and the principles upon which charges should be made for sprinkler service, this Commission has previously spoken in a proceeding instituted by the very interests now before the Commission. That case is that of W. J. C. Kenyon, Manager Traffic Bureau, St. Joseph Commerce Club *et al. vs.* St. Joseph Water Company, P. U. R. 1921 D 590. In that proceeding much the same contentions were made as are now before us though the evidence did not go into such detail as in the present case. The sprinkler users earnestly contend that the principles announced in that case are unsound and we are asked to reconsider the conclusions to which we then came. We are now of the opinion that the contention of the sprinkler users is correct and that our reasoning in the Kenyon case should be departed from. Our decision in the Kenyon case was predicated on the idea that the sprinkler users received special benefits for the service rendered them by the water company and should therefore pay

a reasonable charge therefor. Our views in the Kenyon case were supported by authorities cited in that opinion and the conclusions have been further confirmed by several other commissions and by courts. The following authorities, most of them subsequent to our opinion in the Kenyon case, are cited by counsel for the Water Company as upholding the view that there is a special service rendered to the sprinkler users which should be paid for at reasonable rates:

Re Portland Water District, P. U. R. 1917 D, 907;
Pittock & Leadbetter Lumber Company, *et al., v.* North Coast Power Company, P. U. R. 1920 F, 384, 386;
Terre Haute Paper Company *v.* Terre Haute Water Works Company, P. U. R. 1924, B, 580;
Re Evansville Water Department, P. U. R. 1923 C, 223;
McFuson & Foster Company, *et al., v.* City of Evansville, P. U. R. 1925 E, 248;
Schwarzenbach-Huber Co. *v.* Hackensack Water Co., P. U. R, 1926 A, 701;
Loveman *v.* Waterworks, 1 Tenn. Ch. Appr. R, 596;
Cox *v.* Abbeville Furniture Factory, 75 So. Car. 48;
Gordon *et al., v.* Doran, *et al.,* Board of Water Commissioners, 100 Minn. 347, 111 N. W. 272, 8 L. R. A. (N.S.) 1049;
J. W. Edgerly & Co. *v.* City of Ottumwa, *et al.,* 156 N. W. 388;
Re New Haven Water Company, P. U. R. 1932 E, 7.

It may be conceded that numerically the weight of commission and judicial authority is in favor of the special benefit doctrine announced by us in the Kenyon case. Yet, we are now convinced, after careful consideration of the subject, that reason and logic are against the views which we expressed there. Fundamentally, the basis of the special benefit theory is that because one user can get a greater benefit from the same water service than another user, the first should pay a higher rate. This seems to us unsound and if carried to its logical conclusion would result in gross discrimination and tremendous difficulties in the creation of rate structures. It would mean, for example, that the laundryman who makes a profit out of the use of water for washing clothes should pay a higher rate for the water than, say, the butcher who makes no pecuniary profit out of its use and so on through the whole category of uses of the water. As is pointed out most forcibly in the brief of counsel for the sprinkler users, this theory has been repudiated in the case of rates charged for other utility services. For example, in case of Bailey *vs.* Fayette Gas Fuel Company, (Pa) 44A 251, a rate was disapproved by the court which reflected the proposition that natural gas was worth more to the consumer for lighting purposes measured by what he would have to pay for a substitute, than it was worth for heating purposes as compared with substitute fuel. The court said:

> "The regulation in question seeks to differentiate the price according to the use for heating or for light. It is not claimed that there is any difference in the cost of the product of the company, the expenses of supplying it at the point of delivery, or its value to the company in the increase of business or other ways. The real argument seeks to justify the difference in price solely by the value of the gas to the consumer as measured by what he would have to pay for a substitute for one purpose or the other if he could not get the gas. This is a wholly inadmissible basis of discrimination."

Again when the converse of the situation as to the value to the consumer of natural gas came before the Kansas Commission that Commission in Landon *v.* Lawrence, P. U. R. 1915 E. l.c. 790, said:

> "It has been repeatedly held that neither the value of the service to the consumer, nor the use to which the commodity furnished or transported is applied can properly be made a basis of rate classification."

Again, a telephone company made a rate for telegraph companies which was higher than the rate to business houses for similar services. It was claimed that the telegraph companies derived a greater profit from the use of the telephone in the receipt and delivery of telegraph messages. When this contention came before the Federal Court in Postal Cable Teleg. Co. *v.* Cumberland Tel. & Tel. Co., 177 Fed. 726, the court said:

> "It is clear that a greater charge is not justified against the telegraph company merely on account of the greater profit which it may receive from the telephone service than other business patrons. To consider, as an element entering into the proper charge for service performed by a common carrier, the financial value of such service to the customer, irrespective of the nature of the service rendered by the carrier, would manifestly be to introduce an entirely new basis of regulating its rates of service, directly violative of the fundamental rule that they are to depend upon the character of the service rendered, and one which cannot be supported either upon principle or authority."

The same reasoning has been followed by the Interstate Commerce Commission in Anaconda Copper Mining Co. *v.* Railroad, 19 I. C. R. 596 and Virginia-Carolina Chemical Company *v.* Railroad, 22 I. C. R. 397. The reasoning of these courts and commission commends itself to us and impels us to over-rule our former decision in the Kenyon case.

It is true that in the rule announced in Smythe *v.* Ames the value of the service to the consumer is mentioned as one of the elements to be considered in establishing the rate base and fixing the rates. Obviously, however, the court did not have in mind the value of service in the sense of particular values to different classes of customers nor is the element now regarded as one to be considered by the rate maker except in a general sense.

The sprinkler users also contend that the basis of the charge made for their service is unsound, and so it is. The charge is based upon the number of sprinkler heads in use.

The evidence is that only a limited number of sprinkler heads can be served through the connections in use. For example, a three inch connection will supply only thirty-six heads; a three and one-half inch connection only fifty-five heads; a four inch connection only eighty heads and a five inch connection only one hundred forty heads, etc. It is possible under the present rate structure for a sprinkler user having a four inch connection to pay more than a user having a six inch or eight inch connection. If a user with a four inch connection has 1500 sprinkler heads, he would pay more than a user with a six inch connection having 1200 sprinkler heads, whereas the actual expense chargeable against the sprinkler systems would be less in the case of the four inch connection than in the six inch connection. A number of inequalities of this nature exist in the present rate structure.

In the opinion of the Commission the rates to be charged for sprinkler service should be predicated exclusively upon the size of the connection to

the Company's mains rather than upon the number of sprinkler heads upon the premises.

Criticism is also made of charges for standpipe hose connections and private fire hydrants. There should be no additional charge for standpipe hose connections, for the reason that such hose connections create no expense other than that paid for through the connection. A charge should be made for private fire hydrants, however, to cover the additional expense involved in connection with their installation, operation and maintenance.

There is not sufficient data in this record to enable the Commission to compute the proper charges for private fire protection service. The Commission will therefore make no order in reference to changes in such rates, but will content itself with indicating, as in this section of the report and order, the principles which in its judgment should govern the new rate structure which will be necessary in view of the rate reductions hereinafter ordered and will leave to the management the form of the new rate structure. Such new rate structure will only be interfered with in the event the Commission should find the rates unreasonable as between the different classes of customers served by the utility.

* * *

This decision of the Missouri Public Service Commission thus endorses the principles in which charges for private fire service should be based as expressed in the report of the N.F.P.A. committee on Public Water Supply for Private Fire Protection adopted by the Association in 1932. The decision establishes that sprinkler systems place no additional demand on the public water system and that since the sprinkler user is paying for the general public fire protection service through his taxes, there is no special fire protection service for which he may be charged. It further establishes that any charge should be based merely on the cost of maintenance and periodic inspection of the connections to private fire service lines.

As stated in the N.F.P.A. report referred to above, all of the largest cities of the United States have adopted these principles as a basis for private fire service charges. In these there is either no charge at all or a nominal maintenance or inspection fee.

Planning Inspection Work of Fire Companies.

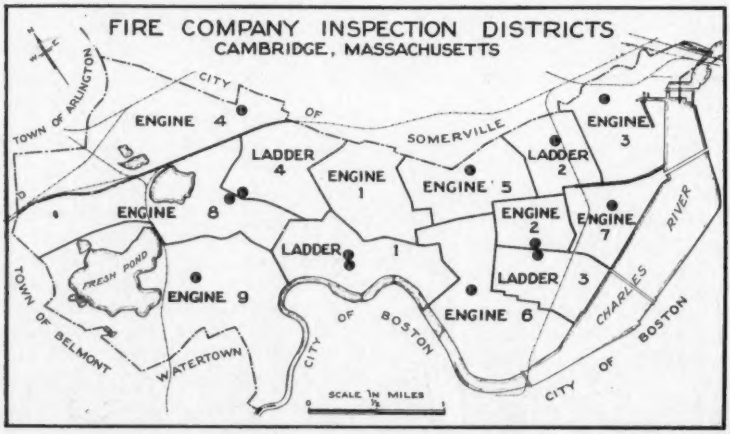
By Horatio Bond,

Engineer, National Fire Protection Association.

Much of the inspection work by the fire department must be done by the various companies in their respective districts. This is true even where the department may have a well-organized Fire Prevention Bureau, as no fire department can afford to assign enough men to the Bureau to provide for all the inspections necessary. Furthermore, inspection work should not be limited to the Bureau or a corps of permanent inspectors, even where it could be so done. Officers and members of fire companies should be familiar with the physical characteristics of the properties in which they may be called upon to fight fires, and this familiarity can be obtained only through inspection work which takes them frequently through these properties.

Inspections by company personnel need careful planning, as companies of five or six men, such as are available in most cities, cannot afford to spare more than one man at a time for this purpose. To show what the inspection problem of a fire company amounts to, that of a typical fire company is here analyzed and one possible method of handling it is suggested.

Following a very common practice, the City of Cambridge, Massachusetts, has been districted for purpose of fire company inspections. As shown on the accompanying map, each fire company has been assigned a certain area of the city for the inspection of which it is held responsible. These districts roughly correspond to the parts of the city to which the company responds on



first alarm. Where two fire companies work from a single station, the first alarm district has been more or less arbitrarily subdivided so that a specific area may be assigned to each company.

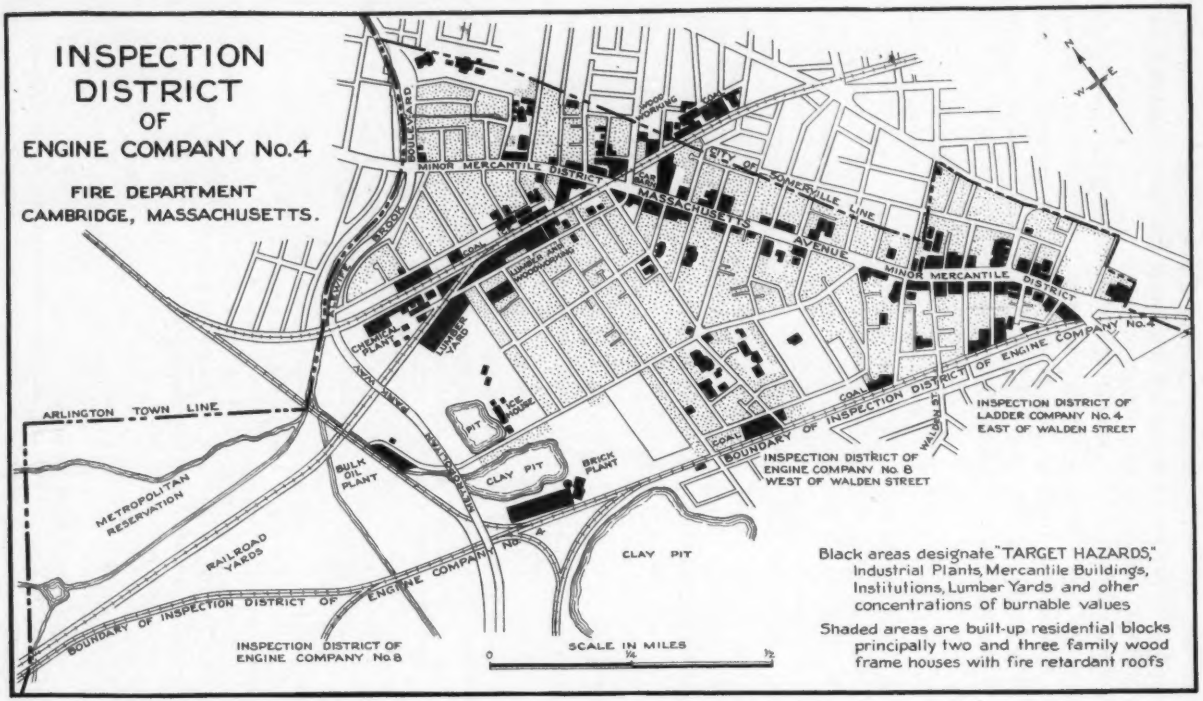
Engine 4 in North Cambridge has been selected as a typical company district to consider here, principally because it is not predominatingly industrial, mercantile or residential, but has an assortment of common occupancies. To show the physical make-up of the district better, a map is also presented herewith which shows the distribution of the hazards, and will be of assistance in "taking stock" of the properties to be inspected.

Target Hazards.

First, attention should be devoted to the "target hazards." This is a convenient name for lumber yards, bulk oil storage stations, industrial plants, mercantile buildings, public and institutional buildings, and other concentrations of burnable values. A complete list of these should be carefully made. When the list is completed, it could be truthfully labeled: "The Places Where the Large Loss Fires of the Future in This District Will Occur." It is in these properties that inspection work will be proportionately more valuable in preventing losses than elsewhere, since it is the properties on the list that constitute the principal destructible values in the district.

Continuing our use of Engine 4's district as an example, its list of target hazards will include the following:

3 lumber yards (large amount of combustible materials).
4 coal and wood yards.
1 bulk oil storage station.
13 storage warehouses (mostly unsprinklered).
7 mercantile buildings (moderate to large areas, mostly unsprinklered housing a total of 27 small retail stores, mostly with offices above).
16 industrial plants. (In spite of serious occupancy and process hazards, the general fire hazard of these plants is local in most cases because of automatic sprinkler protection. Plants include street railway bus garage and repair shop, chemical works, woodworkers, manufacturers of novelties, felt, jewelry, ice, brick, and miscellaneous products.)
1 laundry and 2 small dry cleaning plants.
9 storage garages (larger ones sprinklered).
11 churches and 2 convents.
1 orphanage (large unsprinklered brick and wood building.)
1 small private hospital (in a converted wood residence).
4 public schools and 3 parochial schools.
5 public halls (or lodge rooms).
2 theatres.
1 police station.
1 fire station.
3 recreation department buildings.
5 apartment houses (mostly brick and wood with enclosed stairways, 85 apartments).
7 rows of wood tenements (36 tenements, providing for approximately 98 families).


INSPECTION DISTRICT OF ENGINE COMPANY No. 4
FIRE DEPARTMENT CAMBRIDGE, MASSACHUSETTS.
MINOR MERCANTILE DISTRICT
MASSACHUSETTS AVENUE
CITY OF SOMERVILLE LINE
MINOR MERCANTILE DISTRICT
BOUNDARY OF INSPECTION DISTRICT OF ENGINE COMPANY No. 4
INSPECTION DISTRICT OF LADDER COMPANY No. 4 EAST OF WALDEN STREET
INSPECTION DISTRICT OF ENGINE COMPANY No. 8 WEST OF WALDEN STREET
WALDEN ST.
ARLINGTON TOWN LINE
METROPOLITAN RESERVATION
RAILROAD YARDS
BULK OIL PLANT
CLAY PIT
BRICK PLANT
ICE HOUSE
LUMBER YARD
CHEMICAL PLANT
ALEWIFE BROOK
FRANKLIN STREET
BOUNDARY OF INSPECTION DISTRICT OF ENGINE COMPANY No. 8
INSPECTION DISTRICT OF ENGINE COMPANY No. 8
SCALE IN MILES
Black areas designate "TARGET HAZARDS," Industrial Plants, Mercantile Buildings, Institutions, Lumber Yards and other concentrations of burnable values
Shaded areas are built-up residential blocks principally two and three family wood frame houses with fire retardant roofs

The properties on the preceding list should be visited by at least one member of the fire company or an officer at least four times a year. Each man should know about all important details of the buildings. He should know of what materials the walls, floors, partitions and roofs are constructed. He should know particularly how each building is arranged; how it may be entered, what division walls there may be and where the stairways and other vertical shafts are located through which fire may spread from floor to floor. He must know what contents are stored and in what quantity, what industrial processes are in operation, and the significance of each in case of a fire in the building. He must be familiar with what private fire protection there may be. If there are yard hydrants he must find out how the water system of the property is laid out (usually pumpers should not be connected to yard hydrants). If there is a sprinkler system he should know how it is arranged and where the controlling valves are located. He should also know where standpipes are located.

Not only should every member of the company be familiar with these details, but the above information should be kept on file in company quarters. It should be the company officer's duty to maintain a file including all inspectors' reports on these properties together with a map, plan or diagram recording the essential data about each "target hazard" in the company's district.

Duplicates of this information should be furnished, when desired, to inspectors of the fire department's fire prevention bureau when there is such a bureau and also to inspectors of insurance company inspection departments. "Target hazards" will be inspected by both of these agencies as well as by company members. There is some advantage in having a man from the fire company make at least one inspection a year jointly with the inspectors of these other inspection agencies. In general, it will not be the function of men from the company to issue fire prevention orders. Hazards observed will be reported to the fire prevention bureau and receive proper follow-up by the bureau inspectors. The coöperation of insurance inspectors can also be obtained in securing action on hazards.

Small Unit Properties.

Continuing the "stock-taking" process in Engine 4's district, the following are found:

143 one-story stores.
86 stores in dwellings.
19 small repair shops (plumbing, electrical, auto repair, carpenter, upholstery, painting).
6 gasoline filling stations (underground storage only).

The company inspection work in these small unit properties will be largely to keep rubbish cleaned up and to control the common fire hazards. One way to handle them would be to make a thorough inspection once a year and check up weekly or monthly on rubbish and similar hazards. In the case of filling stations, fairly frequent visits to observe the gasoline handling practices would be appropriate. Detailed inspection records are of much less importance in these properties than in the case of the larger "target hazards."

Dwelling Properties.

Dwellings in most company districts are the most numerous class of buildings. In Engine 4's district the "stock-taking" process shows the following:

Dwelling Occupancies	Approx. No. of Families
5 apartments	85
86 store and dwelling occupancies	121
7 tenement rows (36 tenements)	98
189 1- or 1½-story dwellings	189
1 1½-story duplex dwelling	2
568 2-story dwellings	1136
37 2-story duplex dwellings	148
450 2½-story dwellings	900
25 2½-story duplex dwellings	100
224 3-story dwellings	672
9 3-story duplex dwellings	54
2 parish houses	2
1603 buildings	3507 families

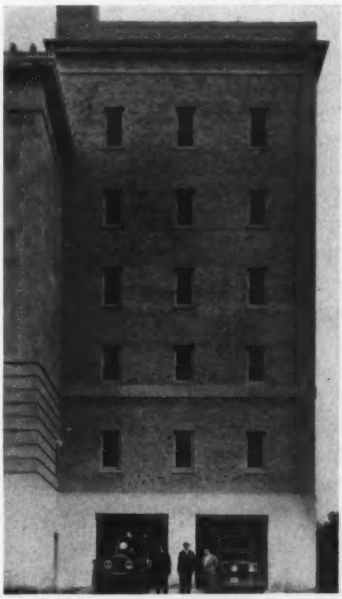
Apartments, Tenement Rows, and Stores and Dwellings are listed in this tabulation, although also listed previously, to make the count of families complete.

Dwelling properties call for treatment somewhat different from the inspection of other properties. There is a very common provision of state laws that specifically states that dwellings, especially one and two-family dwellings, may not be inspected without permission of the occupants. This has led some fire departments to neglect inspections of dwellings. While the home-owner may stand on his legal rights and refuse admission to firemen making inspections, as a practical matter such permission is rarely refused if the citizens are properly approached. One method of reaching dwellings is through a home inspection campaign once or twice a year which has been carried out by a number of cities. (The plan followed in Arlington, Massachusetts, which is one widely used, was described in the QUARTERLY of October 1929, page 132.)

Dwellings are often inspected in connection with a general educational campaign, as in Fire Prevention Week in the fall or Clean-up Week in the spring. Some fire departments leave a piece of literature by means of which the fire prevention message is made to reach each family. For this reason an estimate of the number of families is given in the above table.

It is beyond the scope of this discussion to go into details of inspection work, but by taking stock of what there is to inspect as outlined above and by adopting a plan for the treatment of the three general types of properties listed, the fire company officer in return for the inspection effort applied, can produce maximum results in fires prevented. At the same time he will add greatly to the efficiency of the operations of his company at fires.

Raleigh, N. C., Drill Tower.



The following description of the new Raleigh fire department drill tower is quoted from a letter written by Mr. Sherwood Brockwell (Member N.F.P.A.) of the North Carolina State Fire Marshal's Department.

"I am sending you a photograph of a new fire station and drill tower obtained in a unique manner. When the plans for the new memorial auditorium for the City of Raleigh were sent to this office for approval we noticed a large vacant area at the rear of the building, forming the stage loft and the incline under the stage. Having the fire college complex in our system we got in touch with the fire chief and other authorities and got them to agree to a small additional expenditure (under $10,000), with the result that the Raleigh fire department has one of the best drill towers in the South.

"The stairways, generally erected on the outside of a drill tower, are on the inside of the wall showing in the photograph and, as the inside area is stage loft area, we can, even in rough weather, conduct all of the hose and ladder evolutions inside the building.

"The stage is a large one and this part of the building is so arranged that we can conduct a fire school of 300 pupils, all class work and evolutions, without interfering with any portion of the auditorium, except the stage area.

"The officers of the fire department are extremely proud of this station and drill tower and the 1934 session of the North Carolina Fire College will be held here."

Fire Gases.

By George E. Ferguson.

Every year in the United States about 10,000 people lose their lives because of fires. It has been observed and commented upon that many of these victims are not burned but succumb to the effects of "smoke" and gases. When deaths from this source are reported it is notable that almost never has it been found, specifically, what poisonous gas or gases caused the fatality. When we read of firemen and others who were overcome in fires they are said to have been affected by "smoke" or "chemicals"—both extremely general terms. Occasionally, however, there is an incident, which, because of its peculiar conditions, is analyzed more specifically. An example of this is the Cleveland Hospital fire in which 125 persons lost their lives due to fumes from decomposing photographic films (nitrocellulose). This catastrophe attracted great attention because of its terrible death toll, and a careful investigation was made into the nature of the gases involved (Olsen, Brunjes and Sabetta, *Industrial and Engineering Chemistry,* Vol. 22, page 860, 1930). Another such fire was encountered in the case of the Columbus Penitentiary, where many victims, imprisoned in cells, lost their lives, as was significantly disclosed, by some cause other than heat and flame.

With examples of this sort as a background, a very inviting research suggested itself to Dr. J. C. Olsen, and in this research Dr. Leopold Scheflan and the writer collaborated. The conclusions drawn from the investigation have a very vital and national interest for everyone, and more specially for those who are intimately associated with the study of fire protection engineering.

The present article will not concern itself with the scientific and technical procedure made use of in determining the various compounds under consideration (chemical procedure is completely described in the June, 1933, issue of *Industrial and Engineering Chemistry,* Vol. 25, page 599),* but will limit itself to a study of the significance of the conclusions reached.

It is worthy of note that in fires of all sorts where combustion is maintained by virtue of the reaction of the burning material with the oxygen of the air, it is necessary to consider the products of combustion as produced through a gradation of oxygen supply starting from pure air, or in terms of a fire, "a freely burning fire," through diminishing amounts of oxygen to the point where the diminished oxygen supply no longer supports combustion, *i.e.,* at the point of practical destructive distillation of the burning material.

Every fire which occurs in limited areas and spaces will go through some part of this gradation of oxygen supply, and, as there is no determination

*Reprints of this article are available on application to the N.F.P.A. Executive Office, 60 Batterymarch St., Boston, Mass.

possible of the exact air conditions during the progress of a fire, we must content ourselves with a study of the two extremes—100% air supply on the one hand and, on the other, air in which the oxygen has been depleted to the point of disintegration or destructive distillation without flame, and interpolate the values in between these limits.

Let us consider, for a moment, the results of burning rubber. This happens in the very common electrical fire. Here rubber insulation is both burned and destructively distilled. Investigation of the atmosphere produced by the burning of insulation with abundant oxygen shows most conclusively that carbon dioxide, carbon monoxide, hydrocarbons, hydrogen, hydrogen sulphide and sulphur dioxide are all present, and in sufficient quantity to cause death when breathed for a relatively short space of time.

In the distillation of rubber insulation without oxygen (that is, in the "interior" of the fire area) we measure the gaseous products produced in a diminished or zero oxygen supply. The most notable difference in gaseous products of combustion in these two extremes of oxygen supply is the form of compound taken by the sulphur constituent of the rubber. Where the conditions are free burning, the sulphur appears as sulphur dioxide, where little or no oxygen is available it appears as hydrogen sulphide. Both of these noxious gases in varying amounts, together with the other gases mentioned, go to make up the "smoke," that is, the gaseous products from everyday fires of rubber insulation.

Sulphur dioxide is a toxic gas, hydrogen sulphide is an extremely toxic gas, and carbon monoxide is highly toxic. With these gases in the atmospheres from all rubber fires, how is it that we do not find many fatalities where fires in this material occur? The first two of these gases are highly and offensively odorous. Herein we may find the answer to this question.

Of course, it is significant that in connection with electrical fires facilities for ready retreat are provided in most instances. There are cases where electrical failures have caused distress to those present because of rather restricted air space and the inconvenience of darkness simultaneously operating to cut off escape from exposure to smoke and fumes. Ordinarily, however, the very nature of electricity itself—the danger which is always attendant in conjunction with heavy currents and high tension lines—has constantly operated in favor of providing plenty of room and easy retreat for one whose presence is required where such electrical conditions exist. It must also be remembered that electrical fires are few in ratio to the enormous usage of electricity, and in many instances the breakage of the current eliminates the greatest danger.

The real toxic danger in any fire is, first, the cut-off of escape so that the trapped person must breathe the gases no matter how offensive or repulsive they may be, and second, the production of non-odorous and non-irritating poisonous gases which the victim does not realize he is breathing until too late.

An excellent picture of the value of odors or other warning characteristics of gases is given by Dr. R. R. Sayers in the information circular, "Effect on Workers of Air Conditions" (I.C. 6439, February, 1931, Dept. of Commerce, U. S. Bureau of Mines), where the case of poisonous gases with and without warning properties is stated, referring to a previous study made on poisonous gases, as follows: "Attention was called to the fact that the hazard to health from contamination of air by a noxious gas depends not only on the potential harmful response attending exposure, but also on the warning properties, which in effect may be termed the accompanying warning response. This warning may be manifested as an odor, taste, irritation of the eyes, nose or throat, or perhaps headache, vertigo, or nausea. These manifestations may be painful and even slightly harmful, but to a much lesser degree than the primary injury of exposure. The warning response mitigates hazards directly in proportion to the degree of intolerability which accompanies injurious exposure, and accordingly its absence augments hazards. This accounts for the fact that the actual health hazards from a non-odorous or non-irritating gas or vapor of comparatively low toxicity sometimes equal or exceed the hazard from a considerably more toxic substance, but one which possesses a marked odor or produces eye, nose or throat irritation in advance of harmful exposure."

In the light of the above statement it is interesting to consider the gases produced when volatile oils form the fuel. It is quite true that there is considerable difference in the burning of volatile oils and the burning of cellulose materials, but the gaseous products of combustion are of the same quality in each case, except that the pungent odor (due to acidic gases) produced in the atmosphere from cellulose fires is absent in that from oil fires. Gases formed by burning oil are easily breathed and retained by the lungs.

Carbon dioxide and carbon monoxide, together with decreased oxygen supply, form the basis of this atmosphere—no warning of their presence is given and therein lies their danger to life. The combustion of gasoline in an internal combustion engine in a space not properly vented with fresh air has caused the death of many persons—the case of the running engine and the closed garage door. The difference between the fuel burned in the engine and burned in the air is merely quantitative and not qualitative—the difference in the action on the subject exposed to these two atmospheres is merely a difference in time of exposure.

Probably one of the most common sources of fire is found in that class of materials known under the general heading of "cellulose." Included under this heading are paper and wood with the multitudinous number of products of similar composition. Cellulose fires are found to produce carbon dioxide, carbon monoxide and hydrocarbons beside acid gaseous bodies (these are

generally designated and evaluated under the term "acetic acid"), in sufficient quantities, when formed in the average dwelling room, to be dangerous after short periods of inhalation. Anyone who has been in a building fire or even officiated at a camp or picnic fire will recall the acrid and tear-producing qualities of the smoke, which are accounted for by these pyroligneous acid fumes.

It will be noted that in all the atmospheres studied, carbon dioxide and carbon monoxide are present in rather large amounts. Both of these gases are odorless and practically tasteless. They give no evidence of their presence by irritation to either the nose, throat or eyes. Of the two gases carbon monoxide is by far the most dangerous to breathe; it is too well known to require any discussion of its deadliness here. There is, however, a rather interesting sidelight, which was brought out in the discussion of Dr. Olsen's paper at the meeting of the American Chemical Society and which probably escapes the notice of the casual observer, in connection with the combination of carbon dioxide and carbon monoxide or, in fact, carbon dioxide and any other poisonous gas.

Dr. E. W. Brown, U. S. N. (U. S. Navy Medical Bulletin XXVIII, July, 1930, No. 3, and October, 1930, No. 6) reports extensive tests on the action of varying amounts of carbon dioxide in the atmosphere inhaled by human subjects. He has proved that hyperphea (rapid breathing) and, with higher concentrations, dyspnea (labored panting) are the direct result of the presence of this gas. This effect of carbon dioxide, which has also been observed by other physicians, is made use of in the forced administration of oxygen by adding to the oxygen a small amount of carbon dioxide. The result of this is that the patient receiving the mixture of gases is forced to breathe much faster than normally and thus safely inhales greater quantities of the oxygen for speedier aeration of the blood.

With this knowledge, it becomes obvious that when a mixture of carbon dioxide and carbon monoxide is found in the atmosphere the toxicity of the carbon monoxide is very materially increased, due to the effect on the breathing produced by the carbon dioxide content. In short, a very small per cent of carbon monoxide mixed with air which might be permissible to breathe without serious danger for ten minutes would become fatal in that time if there was present also, in the same atmosphere, carbon dioxide to cause dyspnea, because of the increased amount of carbon monoxide breathed into the lungs per unit of time.

In all of the atmospheres studied, carbon dioxide and carbon monoxide have been constituents produced by the combustion of ordinary common materials so that we may be safe in counting upon both being present simultaneously in the gases from all fires generally encountered. The carbon monoxide content alone is highly poisonous, but mixed as it is with a generous

quantity of carbon dioxide (not in itself particularly toxic) it becomes doubly dangerous.

A study of the gases produced when woolen fabrics are burned or distilled gives most interesting conclusions. It is very difficult to burn wool in air; the material chars and distills more than it burns and therefore the distillates produced in this case assume accentuated value as constituents of the atmosphere. Woolen fabrics, when burned or destructively distilled, produce besides carbon dioxide and carbon monoxide, hydrogen sulphide, hydrocyanic acid (prussic acid), ammonia gas, hydrocarbons and hydrogen in some varying amounts due to variation in burning conditions.

Of these gases particular attention is directed to hydrogen sulphide (the gas most commonly associated with the odor of rotten eggs) and hydrocyanic acid (the lethal gas used in the execution chambers of some of our Western States). Both of these gases are very highly toxic—even more so than carbon monoxide. Under certain conditions of burning, where free access of air is available, sulphur dioxide is also formed in large amounts in place of the hydrogen sulphide. It will be recalled that sulphur dioxide is the gas produced by burning sulphur in air and was used for many years as a disinfecting gas.

It is rather interesting to note the added toxicity of the atmospheres produced the moment we introduce into the burning material those substances which contain nitrogen. Nitrogen seems to be liberated into fire atmospheres in the form of the oxides of nitrogen (film fires), or as prussic acid (woolen goods or silk), or as ammonia (also woolen goods and silk). All of these gases are exceedingly high in the scale of toxicity. The study of the combustion products of silk shows them to be closely allied to those of woolen materials with the exception that the silk produces no sulphur compounds. Copious quantities of prussic acid and ammonia gas, along with the inevitable carbon monoxide, produce dangerously toxic atmospheres where fires in silk are involved.

No one is surprised at a report of death resulting from a person's clothing having caught fire. The results of the investigation of the gases produced by burning wool suggest the interesting speculation as to whether these highly toxic gases are not often the primary cause of fatality. The fact that sometimes, under such circumstances, there is a total absence of or only a minor degree of burns, often leads to the suggestion that the victim "inhaled flame." Nowhere could one be in a better position to receive the full effect of toxic gases from fire than when they are produced directly beneath his nose.

In summing up the results obtained in this research, it was found that every fire gives off gases which are highly toxic. Naturally, if the gases from fires were breathed in high concentrations or only diluted three or four times by normal air, the death rate would be much higher than it is. Fortunately, the ordinary fire is of such size in relation to the room or building in which

it occurs that the fire gases become very dilute and usually do little harm except perhaps to cause a temporary discomfort or a subnormal feeling passing off in a day or two. It is only in those cases where the fire is relatively large in relation to the enclosure that the fire gases commonly accumulate to dangerous concentrations or, as has been pointed out in cases where a fire in a person's own clothing may render it impossible for him to escape them, or where exit is cut off and the victim may be trapped in a longer exposure.

The lessons to be learned or rather the avenues of further study opened up by the story of these experiments seem to be these:

First: The desirability, in fact the vital necessity, of means for quickly extinguishing incipient fires is accentuated. Obviously, the sooner the fire is quelled the sooner will the production of death-dealing gases cease. It is not hard to conceive of cases where, in "slow burning" fires, the gases might accumulate in dangerous concentrations even though the flame did not make great headway. The obvious conclusion is that great emphasis must be laid on the prompt extinguishment of incipient fires.

Second: The necessity for adequate and proper gas masks for municipal firemen whose daily contact with fire exposes them to these dangers and for such private fire brigades as may have the handling of bad fires from the standpoint of inadequate fire gas venting. The specific knowledge of what gases may be anticipated should prove of great value, especially when used in connection with the detailed information on gas masks made available through the Bureau of Mines. (An excellent picture of the Bureau's work on this subject was given by Mr. W. P. Yant, Supervising Engineer, U. S. B. of M., before the Fourth Annual Greater New York Safety Conference early this year, *National Safety News*, August, 1933.) Firemen should heed the lesson to be learned from this research, that poisonous gases do not always give warning of their presence—that the most dangerous are those that do not. In all doubtful cases where a fire has been in progress for any length of time, it is imperative to wear a mask; the mask must be of a type which will protect against any or all of the toxic gases listed herein.

Third: It is entirely possible that the medical profession, being acquainted thus with the more exact nature of the gases taken into the system of a "smoke victim" may be enabled to more accurately treat the condition with the ultimate end of hastening recovery or saving a life.

As important as is the loss of property in fire, it is the death toll from this cause, which is appalling. This problem is worthy of our most careful study and application. If by the scientific and accurate determination of the gases which we all must now admit play a large part in contributing to this death rate, it is found possible to avoid the useless sacrifice of even a few lives, the research will have amply repaid those who carried it out.

Chlorine in Industry.

By Robert E. Stone,
(Member N.F.P.A.)

The use of chlorine and the products of chlorine in industry during the past decade has increased tremendously. From a production of approximately 30,000 tons in the three-year period, 1919-1921, the total amount of chlorine produced has increased to over 200,000 tons annually. Of this, about 60,000 tons are consumed at the plants where it is made, leaving approximately 140,000 tons which must be transported to other plants.

Although chlorine and its products are of tremendous value to man, it is fair to assume that prior to the World War the public, as a whole, knew little about chlorine and its uses. As a result of its use during the war as a poison gas it was, for some time afterward, associated in the public mind as a dangerous chemical in connection with the activities of armies in the field. Today, probably a large number of people who are active in industry or who are interested in the popular aspects of chemistry are familiar with at least one or more uses for chlorine in industry.

The principal use of liquid chlorine is in the chemical industry, which use has been made possible by the ability to produce it in large quantities. This is a development of recent years. Chlorine is extensively used in the paper industry for the bleaching of pulp for white paper. It is also used extensively in the textile industry; quantity production making it possible to produce liquid chlorine at a price which competes with bleaching powder. It is used in increasing quantities for water purification and is at the present time transported to more than 6000 cities and towns in the United States and Canada for the chlorination of drinking water, sewage, swimming pools and other sanitation purposes.

The use and handling of chlorine, like any lethal gas, obviously presents some life hazard. There is a potential fire hazard if during a fire chlorine escapes from its proper containers in sufficient quantity to handicap fire fighting operations, also a remote fire hazard from the chlorine where it may combine with certain other chemicals. The writer believes that the casualty and, particularly, the fire hazard have been overstressed. It is the purpose of this article to present the essential facts, from which the conclusion seems clear that where proper safeguards are observed the use of chlorine is not unduly hazardous, but, in fact, rather less so than many chemicals and other materials commonly used in industry.

Chlorine is one of the chemical elements which, at ordinary temperatures, is a greenish-yellow gas with a strong suffocating odor. Being about 2½ times heavier than air it tends to collect in low places unless diffused by air currents.

Fire Engineering.

A number of large chlorine storage tanks were directly exposed in a fire in this plant. The tanks escaped unscathed and the presence of the chlorine neither contributed to the severity of the fire nor handicapped the fire fighters.

At —28°F., or at 70°F. and a pressure of 86 pounds per sq. in., it becomes an amber liquid. Its critical temperature (i.e., the temperature above which it cannot exist in any other form than as a gas, no matter how great the pressure) is 291.2° F. It combines directly and easily with several other elements. Its attraction for hydrogen is particularly notable on account of useful applications. It decomposes water to form hydrochloric acid, freeing nascent oxygen which exerts a powerful bleaching and disinfecting action.

Chlorine is not found free in nature, but occurs in combined form chiefly as the chlorides of sodium, potassium, calcium and magnesium. Of these compounds, chloride of sodium (common salt) in form of rock salt or brine is the usual source of chlorine produced in the United States. Incidentally salt is probably the cheapest compound of chlorine. The form in which chlorine enters commerce is as a heavy liquid. It is, in fact, a compressed gas, but as it is held in containers under pressure it is known as a liquefied gas. It is made by decomposing solutions of sodium chloride (common salt) with a direct electric current of low voltage and high amperage in what is termed a "cell." The salt solutions are thereby decomposed and three substances, chlorine, caustic soda liquor and hydrogen are simultaneously formed.

Chlorine as a gas is extremely disagreeable and injurious to breathe and even in comparatively low concentrations attacks the membranes of the nose, throat and lungs, causing irritation and inflammation. If inhaled for a prolonged period, in concentrated form, it may cause death. It is significant,

however, that it produces no cumulative effects and complete recovery from the effects of mild exposure to chlorine may be expected. Fortunately chlorine is readily detected in the air before it is present in dangerous quantities due to its noxious odor and irritating action on the respiratory system.

Chlorine is non-combustible, although if combined with hydrogen, acetylene and certain other organic materials it may combine or react with explosive force. In certain industrial operations organic materials have been sucked back into chlorine containers, resulting in an explosion. Likewise water sucked back into containers when nearly empty and before control valves could be closed has resulted in the rupture of the chlorine containers. In this respect, chlorine, in or out of containers, is no more explosive than are various other materials commonly used in industry.

Storage and Handling.

All chlorine containers should be stored outside of important buildings and away from combustible materials. An incombustible open shelter well away from buildings and accessible to hose streams is a desirable safe storage place. Tank cars for storage should be prohibited in mill yards or congested districts, and at isolated plants cars should be as far as practicable from buildings and to leeward of prevailing winds. If necessary to have cars near buildings it is desirable to make exposing wall of building blank.

Pipe lines from containers should have safely located shut-off valves. When air is used for handling chlorine, it should be thoroughly dried. Ordinarily the vapor pressure of the liquid is sufficient to force it to the point used. Cylinders or ton drums should never be heated to force gas delivery. If a faster rate of flow is desired than can be obtained from chlorine vapor pressure alone, the liquid should first be run to an approved type thermostatically-controlled water bath vaporizer.

Liquid chlorine is shipped in steel cylinders of 100 to 150 pounds capacity, ton drums, or tank cars of 16 and 30 tons capacity, all of which are made and tested in accordance with the requirements of the Interstate Commerce Commission. The cylinders and ton drums are provided with soft fusible plugs and tank cars are fitted with safety valves. Tank cars are provided with heavy insulation lagging to prevent undue heating in transit.

Chlorine, especially if moisture is present, is corrosive and may thus cause the rupture of containers. Chlorine containers should be used in rotation and after use be returned to the manufacturer for periodic testing and examination for condition and strength.

Chlorine gas is to be feared chiefly on account of its suffocating effect and the possibility of its escape resulting in panic. One of the things to be remembered about chlorine, however, is that in the event of a small puncture the cooling that takes place within the tank reduces the velocity of the flow

through the puncture. The rate of evaporation of the escaping gas is slow.

As chlorine is a non-flammable gas the fire hazard is reduced primarily to the hazard incidental to the gassing of fire fighters in the vicinity of stored material. Containers heated by exposure to fire may be destroyed by direct combination of the steel with chlorine or may explode, due to failure of fusible plugs to release built-up pressure. The use of fusible plugs and safety valves, however, greatly reduces the potential hazard. In fires, when fumes escape due to the overheating of chlorine containers they are frequently carried upward with the gases of combustion and cause no ill effects. Inside buildings, confined gas may hamper fire fighting and disable fire fighters. As is indicated by the fire and accident record, escaping gas from tank cars has caused panic, destruction of vegetation within the surrounding area, temporary injuries to employees and corrosion to piping and equipment. Such occurrences have been comparatively rare, however, and practical experience seems to indicate that the hazards are not so serious as might be feared, and that most emergencies may be handled without extensive damage being done or resulting in serious injury or loss of life.

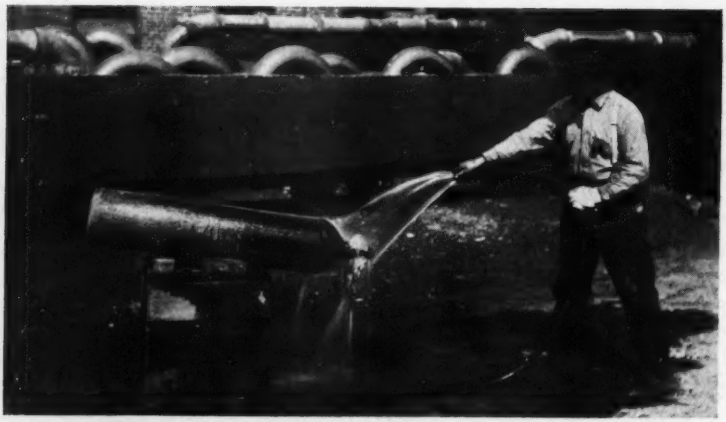
Factory Mutuals.

The fusible plug on this chlorine cylinder operated in a fire, but before all pressure had been relieved the high temperature caused the chlorine to burn a hole through the cylinder as shown.

Effect of Fire on Filled Containers.*

To note the effect on liquid chlorine in cylinders when exposed to fire, a series of tests was conducted by the Factory Mutual Laboratories in coöperation with the Electro Bleaching Gas Company at Niagara Falls, N. Y. A cylinder of the gas was exposed to a wood fire out in the open. The fusible plug operated in one minute, but no odor of gas was noticeable a short distance to windward nor at right angles to the wind, but to leeward for a distance of about two hundred and fifty feet the gas was strong enough to require the protection of a handkerchief over the nose and mouth.

*This section is reprinted from the *Factory Mutual Record.*



Factory Mutuals.

Above: Operator playing hose on stream of liquid chlorine escaping through open valve of partially inverted cylinder. Note formation of chlorine hydrate.

Left: Mass of chlorine hydrate formed by playing hose on stream of liquid chlorine. Note that no escape of chlorine can be seen, although valve is still open.

After ten minutes the temperature had risen to a point where the chlorine attacked the steel (this takes place at about 300° F.), and a hole was burned through the cylinder, releasing a large cloud of gas, which extended for five hundred feet to leeward.

Fire tests on ton drums of liquid chlorine, conducted by the Bureau of Explosives in New York City, demonstrated that the fusible plugs would operate and relieve the pressure without exploding the containers. In fire tests on a tank car of liquid chlorine the temperature of the contents rose one hundred degrees, and the pressure increased from forty-two to one hundred and fifty pounds, above which it could not be raised with the heat available. No serious trouble developed.

Several fires have occurred in which cylinders of liquid chlorine were involved. In general it has been found that the gas will escape and be carried upward by the current of hot gases, so that the blaze can be fought safely on the windward side as well as on the two flanks. In some cases fusible plugs have failed to operate during a fire, and explosions of the cylinders have resulted, releasing sufficient quantities of the gas to interfere with fire fighting.

The failure of the fusible plugs has been recognized as a weakness for some time, and efforts have been made to discover a remedy.

Transportation Accidents.

Conclusive proof of the comparatively slight hazard of chlorine in transit is indicated by the summary of accidents recorded by the Bureau of Explosives, involving compressed chlorine gas in rail transportation from 1911 to 1929, inclusive. During this period there were recorded 42 accidents resulting in an aggregate loss of $2688 and injury to approximately 127 persons. Of the total number of personal injuries 70 occurred in connection with the leakage of chlorine from a leaky valve on a tank car at Altoona, Pa., in 1928, and apparently all these injuries were slight.

Of the transportation accidents reported by the Bureau of Explosives, 36 involved chlorine cylinders of 100 to 150 lbs. capacity, 3 involved ton containers and 3 tank cars. The causes of cylinder accidents were varied, but chiefly involved valves. The causes of valve failures were as follows:

Leak at valve	7
Broken valve or valve cap	7
Defective valve	5
Valve not closed	1

The causes of ton container failures were defective fuse plugs, container ruptured in railroad wreck and failure of container at joint weld. But one injury resulted from these accidents to ton containers. The causes of two of the three tank car accidents were derailment and leaking at gas valve seat. Details of the third accident are not available.

Typical Chlorine Accidents Not Involving Fires.

NOVEMBER 18, 1920. MAYSVILLE, KY. RAILROAD CAR. Due to defective fuse plugs, chlorine gas was liberated from a ton container on a car in a train standing in the station. One person was gassed by the fumes released.

FEBRUARY 14, 1921. SOUTH HADLEY, MASS. PAPER MILL. An explosion occurred in a bleach tank in the rag room of a mill. When a window was opened a back draft occurred, blowing the chlorine fumes back into the room. Thirteen women were gassed, four of them seriously.

JULY 26, 1922. GROTON, MASS. PAPER MILL. This accident occurred at noon when a locomotive was switching cars on a siding. The brakes on the train did not work well and the cars were backed over a 12″ x 12″ timber (chained and locked to track ahead of tank car) and hit a tank car containing liquid chlorine. A ¾-inch pipe from the car to the mill broke at the tee into which pipes at the top of the car enter. The valves were open and the gas escaped into the air until stopped by the operator, who succeeded in closing the valves.

The operator wore a gas mask, but due to improper adjustment got a dose of gas. When he attempted to adjust the mask he got a second dose. The gas penetrated the mill and caused some discomfort to employees. It also caused considerable corrosion to brass and other metal work. Leaves, grass and other vegetation were destroyed and dried up for a distance of approximately ¼ mile. To the windward, however, and on each side of the path taken by the gas no one was affected or aware of the accident.

JUNE 28, 1923. NEAR PITTSBURGH, PA. METAL WORKER. Chlorine was used at this plant in the process of recovering tin plate from scrap. A tank car had been piped to the process building with ¾-inch extra heavy pipe and instructions had been issued that no switching was to be done on this particular siding. In spite of this order, at 8:00 A.M. a tank car full of liquid chlorine was bumped by a locomotive crane and the gas discharge pipe was broken off.

There was no breeze blowing, which resulted in a dense cloud of gas forming about the tank car so that no one could get near it to shut the valve. Later a breeze sprang up, blowing the gas away and making it possible to close the emergency valve. Employees remained in the plant at safe distances and no one was injured.

OCTOBER 5, 1923. MANAYUNK, PA. TEXTILE PLANT. Sixteen ton-containers were in storage. One was connected by ¼-inch copper pipe passing under the floor to a bleach mixing tank. When the operator opened the valve after connections were made, a leak developed. It is probable that he jumped away from the leak and was unable to return on account of fumes. A near-by gas mask could not be reached and the fire department was called to get another. Meanwhile, hose streams were played on the leak, hoping to freeze enough water around the leak to stop it (temperature of the gas was —30°F.), but this was not successful. A gas mask was finally obtained and the gas shut off. About 45 employees were more or less affected by the fumes.

APRIL 3, 1924. NOLAN, W. VA. RAILROAD WRECK. Three ton-containers were thrown from a car containing fifteen containers when a train was wrecked. Two of these suffered no damage and lost none of their contents. The third container was ruptured and its contents released. No one was gassed and the chlorine was apparently dissipated without doing any harm.

SEPTEMBER 26, 1929. BERLIN, N. H. PAPER MILL. A locomotive was switching cars at night. Contrary to orders, the switching crew (in order to place a box car temporarily on a spur track) operated a switch on a track leading to a shed where chlorine tank cars were unloaded. There was no one on the box car to manipulate the brakes, and as couplings were pulled prematurely and there was a slight down grade, the box car entered the siding without control. The trainmen attempted to make connections with the car, but the coupling was closed and it only resulted in another push for the free car.

The derailing switch was open and the car entered the vacant side of the chlorine unloading shed. As it did so, the brake wheel on top of the car struck the wood bracing in the roof which supported a 1-inch unloading pipe from a chlorine tank car on the other track in the shed.

Mill and city firemen were immediately notified and the escaping gas was fought with hose streams from mill hydrants until it became possible to shut the valve on top of the car and save about 2000 lbs. of gas remaining. Two mill employees with weak heart action were seriously affected, but recovered. Considerable discomfort was experienced by many people in the city located on the river below the mill, but no serious results were noted.

OCTOBER, 1930. DENVER, COLO. CLAY PRODUCTS PLANT. Chlorine gas escaping from a tank car affected 26 persons, including 13 firemen. The leak occurred as a crew of men were transferring the liquid chlorine from the tank car to cylinders. The first fire company summoned by employees hoped by cooling the tank to freeze the leak. When this proved unsuccessful an employee with a gas mask climbed the side of the tank car and shut off the valve.

Typical Fires Where Chlorine Was Involved.

In the foregoing text it has been pointed out that there is a potential life hazard in the escape of chlorine gas, so that an accident may prevent fire fighting under unfavorable conditions. On the other hand, liquid chlorine containers can usually be reached and fires fought from the windward side, so that the use of liquid chlorine by men thoroughly trained how to act in an emergency is not believed to materially retard the controlling of fires in industrial plants. The following record of typical fires is indicative of the potential hazards involved.

FEBRUARY, 1921. MERITTON, ONTARIO. PAPER MILL. An insulated tank car was located about 36 feet away from a one-story wooden building, 40 feet by 80 feet, filled with barrels and scrap paper. The building caught fire and was destroyed. It was impossible to remove the car from the fire zone and radiated heat from the fire heated the steel shell over the lagging so hot that a hand could not be held upon it. Three hours after the fire started the mill again began drawing chlorine from the car, and it was noted that the pressure in the car had risen but 10 lbs., due to the fire.

JULY 6, 1922. MICHIGAN CITY, IND. WATER WORKS PUMPING STATION. Fire originated in an adjacent ball park from an unknown cause and communicated to the pumping station. The fire destroyed the entire roof of the building and lasted about three hours. The fire involved five cylinders of liquid chlorine, which were stored in the building. Neither the chief of the fire department nor any of the firemen were aware of the presence of the chlorine or knew that it was liberated during the fire. Insofar as it could be learned, no one was affected by the fumes. Yet the five cylinders which were in the oil room were found in damaged condition after the fire. Three had

jagged openings at the top as though the container had been subjected to great pressure before failure, one had lost its cap and valve fitting, and one was fused at the head with cap and valve in place. Hot gases of combustion probably carried the fumes upward.

AUGUST 10, 1924. WALPOLE, MASS. PAPER MILL. A fire occurred in a wagon shed used for miscellaneous storage, consisting of old waste rope, rosin in barrels, wagons and forty-five cylinders of liquid chlorine stored there as a reserve supply. Although three hose streams were brought into play by mill and town firemen within a few minutes, the building and contents were practically destroyed.

The fusible plugs in most of the chlorine cylinders operated properly and the escaping gas was carried upward by the heat and dissipated by the smoke. Three of the cylinders, however, exploded. Two moved only a few feet, but the third was blown through the roof and landed in a field about 200 feet away. Examination of the ruptured cylinders showed jagged tears which extended the entire lengths of the containers. Several of the firemen fighting the fire on the leeward were somewhat affected by the fumes of the chlorine gas from the cylinders which exploded. Mill employees fighting the fire from the windward side suffered no difficulty from fumes.

An investigation of the cause of the explosion of the three cylinders indicated that failure was due to excess pressure generated in the cylinders when the fusible plugs did not work. It was found that the fusible plugs had not operated, due to corrosion which had affected the solder at the inner end of the plug, rendering it infusible.

JULY 18, 1925. HOBOKEN, N. J. WAREHOUSE. A fire which threatened the entire waterfront occurred in one of a group of three buildings constructed of sheet corrugated iron, each building 500 x 70 feet, used for storage purposes. The building in which the fire started contained large quantities of baled rags, tobacco in hogsheads and bales, carbon black, rope, some machinery and electrical supplies, 37 automobiles, some miscellaneous chemicals, and 75 cylinders of liquid chlorine.

When the fire department arrived one building was completely involved and the fire had communicated to the one adjoining. The chlorine in the cylinders was released and several firemen were affected by the fumes. One of the tanks exploded, piercing diagonally through the structure containing the automobiles, and emerging at the front of the structure, narrowly missing a group of firemen. Following this a number of the other cylinders exploded.

MAY 10, 1929, SYRACUSE, N. Y. CHEMICAL WORKS. An explosion of unknown origin involved a large tank containing chlorine, together with the building in which it was housed. One workman who was in the room at the time of the explosion was so badly gassed that he later died. Several others were affected by the fumes. The gas spread across the country and was

Fire Engineering.

View of burning warehouse at Hoboken, N. J., which contained, among other merchandise, 75 cylinders of liquid chlorine. Several tanks exploded. (See description of this fire on preceding page.)

finally dissipated over a near-by lake. No casualties resulted from the gas outside of the structure in which the initial explosion occurred.

JULY 15, 1929. PHILADELPHIA, PA. PIER AND WAREHOUSE. When fire destroyed a large pier and warehouse an unknown amount of liquid chlorine in cylinders was involved. From newspaper accounts of the fire it appears that at least one cylinder failed to release its contents and exploded, being carried a considerable distance by the force of the explosion. Chlorine gas swirled out with a smoke in yellow clouds, but as far as was known no one was affected, although the presence of the gas somewhat hampered firemen working on the smouldering ruins after the fire was under control.

OCTOBER 28, 1932. EAST PITTSBURGH, PA. ELECTRICAL EQUIPMENT. This fire originated in a small unsprinklered building used as a laboratory for development work. Several cylinders of liquid chlorine were in the building and when the fusible plugs operated the gas was liberated. The chlorine fumes escaping, hampered the firemen to some extent in fighting the blaze.

Methods of Controlling Leaks.

Chlorine is readily detected in concentrations far below that which is ordinarily dangerous. The greatest danger is that of sudden exposure to a high concentration such as may occur when a pipe or valve is broken. This danger is particularly acute where chlorine is in a liquid state and under more or less pressure promoting rapid vaporization.

When the gas escapes in the open, and under some conditions indoors, it is possible with the protection of a gas mask to approach the tank and close the controlling valve. It is essential that some form of protection be provided for emergencies. A sufficient number of suitable gas masks should be readily available. Almost all types of modern gas masks are capable of absorbing chlorine in low concentrations, but masks offering particular protection against chlorine should be provided where high concentrations of chlorine are possible and employees should be trained in their use.

When the liquid rather than the gas escapes, an effective means of stopping the flow is to spray the liquid with water, forming chlorine hydrate, a white solid. In an experiment made by the Factory Mutual Laboratories the application of water to a stream of liquid chlorine flowing from the open valve of a 150-pound container formed an icicle of chlorine hydrate, which gradually enlarged until the stream issuing at one hundred pounds pressure was completely shut off. Chlorine hydrate is not a stable chemical compound, for it breaks up into water and chlorine at ordinary temperatures, but the decomposition takes place slowly, and the material can therefore be safely handled.

Precautions and Safeguards.

With the following precautions and a crew of men who know what to do in an emergency, the hazard of life and property connected with the use of liquid chlorine will not be serious.

1. Store cylinders or ton drums of liquid chlorine in a detached building, preferably of incombustible construction, where they will not be exposed to fire or mechanical injury.

2. Place tank cars of liquid chlorine on a spur track with derailing switch to avert collision.

3. Pipe systems generally used in tank cars introduce some dangers and should be of extra heavy pipe supported securely and provided with flexible connection of copper tubing at the car.

4. Vaporizing rooms should be of gas-tight construction and well cut off from the main manufacturing rooms.

5. A liberal supply of gas masks should be provided to protect employees in case of emergency.

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Rural Fire Department Field Demonstrations.

By Willard B. Hall.*

One of the most interesting developments in the science of fire fighting in recent years has been the increased use of pumpers and the more efficient utilization of existing water supplies by rural fire departments. These factors have materially increased the efficiency of the departments and have resulted in the saving of property which otherwise might have been a total loss.

Among the many fire fighting organizations throughout the country which have been studying ways and means for greater efficiency in fire fighting and consequent decreased losses in their territory is the Woonasquatucket Valley Firemen's League of Rhode Island. This league, embracing a territory adjacent to the city of Providence, is made up of twelve volunteer fire companies from districts that vary from near city conditions to a crossroads where there are scarcely enough houses to call it a village. An unusual opportunity came to this organization to combine theoretical discussions with practical laboratory experience when the league firemen were allowed to burn two dilapidated old houses that were about to be demolished.

It was necessary if such fire tests were to be a success that study and preparation be made to determine the exact manner in which the tests should be carried out and what specific problems should be studied. An engineering committee for the league outlined the work and made arrangements for time keepers and observers to record all important data.

At the first fire the primary object was to arouse public interest in better fire protection, but the actual tests proved the effectiveness of utilizing small capacity fire department pumpers to relay water from distant supplies. In the first test 2½-inch hose was used and observations were made to determine (1) the greatest practical range of operation at rural fires, (2) the proper system or order in which pumpers should be placed, (3) what results might be expected at a rural fire if the alarm was sounded with reasonable promptness. The second fire was conducted as a test to determine the effectiveness of small hose streams at rural fires where only a limited quantity of water is available. Details of the actual fire tests follow. It is important to note that fire departments taking part were all well qualified as a result of holding practice drills so that they were familiar with their work which precluded reasonably effective operation. There were no near-by buildings to be endangered in either of these fire tests and due precautions were taken to prevent the spread of fire to grass or woodland.

*Chairman, Engineering Committee, Woonasquatucket Valley Firemen's League.

This picture shows good streams (2½-in. hose, 1-in. tip) from several pumpers working in relay. One stream was used to wet the grass to prevent spread of fire to near-by woodland.

The first test took place several years ago when the League obtained an old house near the village of North Scituate, R. I. It was located 2300 feet from a large pond and the engineering committee saw in this lay-out an opportunity to demonstrate the efficiency of relaying water from one pumper to another to the point of the fire. The primary objects of the demonstration were to arouse interest in better fire protection for the village of North Scituate and to show that by pumping in relay, property at considerable distance from available water supplies could be protected. The run of each pumper taking part in the test was timed, pressures were recorded at frequent intervals and numerous pictures were taken.

Prior to the start of the demonstration pumpers from Harmony, Lymansville and Smithfield companies were stationed at a point a half mile beyond the dam at the reservoir. When the torch was applied to the building, word was telephoned to the pumpers and they were started on their way as to an actual fire. The run to the dam was made, suction thrown overboard, hose laid, the pumpers connected up and water was on the fire in 6½ minutes. The old house, with the windows removed, permitting maximum draft conditions, was well on fire and gave indication of being a total loss. Nevertheless in 33 minutes the fire was out and most of the building standing. Two streams (2½-inch hose, 1-inch nozzle tips) from the last pumper in the line had stopped the fire as quickly as though the house had stood on a city corner instead of about half a mile from the nearest water supply. As a result of this demonstration, the fire company at North Scituate acquired a new pumper.

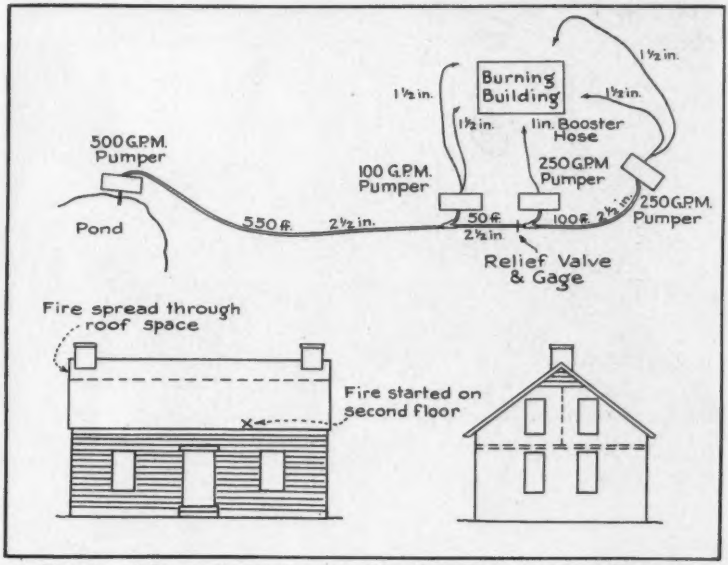


Diagram of demonstration fire staged by the Woonasquatucket Valley Firemen's League of Rhode Island to show the value of 1½-in. hose streams in fighting fires in dwellings. The pumpers were placed as shown for demonstration purposes only. The 1½-in. lines might be supplied with smaller pumping capacity.

From that day on, the firemen were on the lookout for another house. Early in the spring of 1932 another such house was found. As all of the windows and doors, some of the weather boarding and some of the flooring of this house had been removed for salvage purposes, the condition of the building made it impossible to work out problems in ventilation as first planned, so it was decided to make use of it to test the value of 1½-inch hose streams using ½-inch nozzle tips in extinguishing fire with minimum water damage. There had been some hesitancy on the part of some of the companies in the League toward the use of small hose streams for fear that this might result in the loss of a building.

The house to be burned was situated on a narrow side road and there was no point to be gained, except realism, in making a demonstration run to the fire. Therefore, the apparatus was placed before the fire was set. A 500-gallon per minute pumper was stationed at a pond near by and 600 feet of 2½-inch hose was stretched to a point near the building. By use of Y-connections the suction sides of three small pumpers, one of 100 G.P.M. capacity, one of 250 G.P.M. capacity and one of 350 G.P.M. capacity, were connected to this line. A relief valve was provided to take care of excess back pressure when lines were shut down and a gauge was set into the line

The fire was well under way before water was applied. Four streams from 1½-in. hose lines sufficed to bring it under control at this stage without severe damage to the lower floor.

for recording purposes. From each of two of these pumpers (the 100 G.P.M. and 350 G.P.M. pumpers) two 100-foot lines of 1½-inch hose were taken off, and from the third pumping was direct through the ¾-inch booster tank hose on the apparatus. The last line was used to protect the shade trees in front of the burning house.

The house was ignited on the second floor. When the fire had reached sufficient proportions so that flames were coming out under the eaves, from the windows at one end and through the wooden shingle roof in two places, orders were given to attempt to extinguish it. This was accomplished by taking hose lines over ladders into the windows and up the stairway. The fire was promptly brought under control but not extinguished as it was desired to continue the demonstration.

The fire was then allowed to continue until the entire second floor and roof were a mass of flames. An attempt was made to extinguish it at this point, but this attempt was also discontinued before definite control had been established. However, it seems probable that with the four streams in operation, this fire probably could have been extinguished without severe fire damage to the lower floor, although the whole second floor would have been gutted and the roof burned off. After this test, fires were started on the first floor and the building allowed to burn down. The total destruction of the building was part

of the contract with the Providence Water Company, who owned the building and who wished to get rid of it.

Conclusions.

The conclusions reached by observers at these test fires were that volunteer fire departments with reasonable training and proper equipment have a greater practical sphere of operation than was formerly believed possible. Even limited and distant water supplies were proven to be effective sources of supply.

The tests very clearly demonstrated that 1½-inch hose streams with ½-inch tips can be very effective on residential fires. Their mobility and ease of handling make them particularly adapted to inside work and when a limited number of firemen may be on hand to handle hose streams in the early stages of a fire. The fact that they are economical in the use of water is a distinct advantage in keeping water losses at a minimum and in conserving limited water supplies. The test further demonstrated that 1½-inch hose streams are far more effective than chemical or booster lines with ⅜-inch or ¼-inch tips which are limited in volume and range.

Such practical fire laboratory experiments present almost limitless possibilities for study of any problem which the firemen may want to solve. Moreover, they not only provide an opportunity to make experiments, but are a source of interest to volunteer firemen who gain much practical experience thereby.

LET EVERYBODY HELP!

Providence Journal.

Fire Hazard Tests With Cigarettes.

By F. M. Hoffheins,
U. S. Bureau of Standards

The purpose of the tests reported herein was to develop a modification of cigarettes which would considerably reduce their fire hazard when discarded and also be acceptable to manufacturer and consumer. A previous study of this problem by the Bureau of Standards was reported in the QUARTERLY of the National Fire Protection Association, January, 1928, Vol. 21, No. 3, page 237. The work was undertaken and continued to the present stage at the request of a member of the Congress and of organizations interested in the prevention of fire loss.

The average annual fire loss for the five-year period 1927-31 attributed to "matches-smoking" was about 29 million dollars as reported by the Actuarial Bureau of the National Board of Fire Underwriters. This was one-seventh of the 200 million-dollar loss from known causes. The estimated total annual loss for the same five-year period was 470 million dollars, which includes also the loss from unknown causes and an allowance for unreported losses. If losses from the given cause enter into the total loss to the same extent as into that from known causes, the average annual loss attributable to "matches-smoking" would be nearly 70 million dollars. While the loss due to cigarettes cannot be segregated from losses due to matches, cigars and pipes, when it is considered that the annual cigarette consumption is about a hundred billion (which means that on the average 190 thousand are discarded each minute), it will be realized that their potential fire hazard is not small.

Any modification of the cigarette acceptable for the purpose must produce an appreciable reduction in fire hazard without noticeable inconvenience to the smoker and also permit its successful application to modern manufacturing processes. Tipping of the cigarette was selected as the most practical means of reducing the fire hazard, since it does not affect the burning properties of the untipped portion nor add appreciably to the cost of manufacturing. The tips should not impart disagreeable odor, smoke, taste, or discoloration and should be sufficiently noticeable to enable the user to readily identify the tipped end. Tipping with cork and with paper is already in use in commercially marketed brands, so that the application of tips to cigarettes can be considered practical from a manufacturing standpoint.

The degree of reduction in fire hazard is limited by the length of tip that can be used. The previous study of the frequency of occurrence of

Publication approved by the Director of the Bureau of Standards of the U. S. Department of Commerce.

cigarette butts of given lengths showed that the 1¼-inch cigarette butt is the one most frequently discarded and that two-thirds of the number observed had lengths between one and 1½-inch. (Figure 1.)

Description of Cigarettes.

The cigarettes used in these tests included five untipped, one cork-tipped, and one paper-tipped, popular fast-burning brands, and one untipped popular slow-burning brand. (Table 1.) The cork-tipped and glazed paper-tipped brands were introduced to determine the difference in fire hazard between commercial tipped and untipped cigarettes.

The term "fast-burning" is here applied to the cigarette that will burn up completely without relighting when suspended in vertical position. Most of the cigarettes now on the market are of this type. In determining the time of burning reported in Table 1, the cigarette was suspended vertically in still

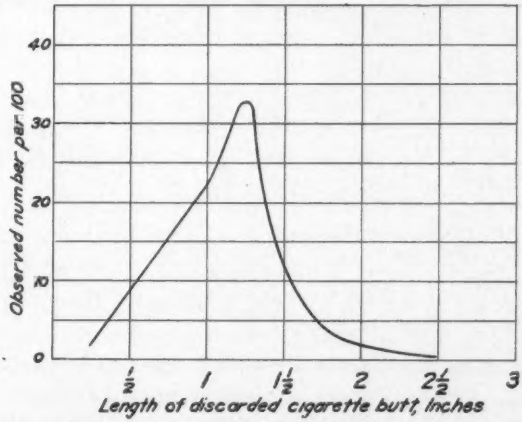


Fig. 1. Frequency of occurrence of cigarette butts of given lengths.

air and lighted at the lower end. The full length of the cigarette was 2¾ inches, except for those of brand No. 8, which were 2.9 inches long.

Cigarette paper was used in the special tips applied to cigarettes for these tests, since it alone appeared to meet the requirements that are outlined above. Other materials, such as cork, were not used as they would not be acceptable if smoked past the end of some of the longer tips. In trials with a number of smokers it was found that the cigarette paper tip did not introduce any inconvenience when the cigarette was smoked past the end of the tip, nor impart disagreeable smoke or odor.

The paper for the special tips was obtained either from the slow-burning manufactured cigarette No. 8 or from a paper sold for hand-rolled cigarettes.

Table 1. Data on Cigarettes.

Brand No.	Weight Grams	Apparent Density G/cm.3	Time to Burn Full Length Min.	Type
1	1.10	.27	16.7	Fast-burning
2	1.09	.26	18.6	Fast-burning
3	1.04	.25	19.8	Fast-burning
4	1.06	.25	19.8	Cork-tipped, fast-burning*
5	1.04	.25	20.2	Glazed paper-tipped, fast-burning
6	1.10	.27	20.7	Fast-burning
7	1.06	.26	21.3	Fast-burning
8	1.07	.25	†	Slow-burning

*The time to burn full length was computed from the time required to burn the untipped length.

†This brand would not burn continuously.

These were applied by hand with starch paste and either sealed on by pasting both edges or by coating the whole tip with the paste; the former method is referred to as "sealing" and the latter as "coating." The paper from the slow-burning cigarette was applied by the latter method, and the other paper by both methods. Tips of various lengths were placed over the paper of the several brands of fast-burning cigarettes.

Chemical analysis of a composite sample of paper from cigarettes of brands Nos. 1 to 7 indicated a content of inorganic filler of approximately 17 per cent, which was composed mainly of calcium carbonate. Analysis of the cigarette paper used for tips gave nearly the same results. In reporting the results of tests with tipped cigarettes, this paper will be designated as "fast-burning." Analysis of the paper from brand No. 8 gave approximately 8 per cent inorganic filler, likewise largely calcium carbonate. The slow-burning properties of this type of cigarette are generally attributed to the lower filler content of this paper.

Description of the Combustible Materials Exposed to Burning Cigarettes.

The grass was of miscellaneous fine-blade varieties. Part of it was dead grass dried from the preceding season and the rest cut grass dried and seasoned for one month or more. The blades were in general four or more inches long. The grass was packed in the pads to give an apparent density of approximately 0.043 gram per cubic centimeter. The moisture content, as determined by drying at 212° F., ranged from 7 to 9 per cent after attaining equilibrium at 30 to 40 per cent relative humidity, and about 12 per cent for 60 to 80 per cent relative humidity.

The other materials were samples of organic materials from forest floors. They were cut into 3 by 3-inch pieces and placed in the test tray without disarrangement of their respective layers, and were thus in the condition as taken from the forest floor with the exception of the moisture content. The latter was determined for each sample before test and varied with the relative humidity maintained during the given test. In all cases the moisture content

was between 5 and 14 per cent, thus placing the materials as tested within the zones of extreme, high, and medium flammability, according to designations that have been used.* No tests were made with a material until it had remained in the test room under a given condition of humidity and temperature for four or more hours.

The various forest floor materials which were used in the tests are listed in Table 2. The organic remains composing the forest floor are divided into (1) the litter proper or loose débris of dead sticks, leaves, branches, and twigs lying at the surface, (2) the duff or partly decomposed vegetable matter beneath the litter, and (3) the humus or thoroughly decomposed organic layer found between the mineral soil and the duff. All of the forest materials used in these tests were either litter or duff with the exception of the disintegrating wood. The latter, while retaining its original structure, had decayed to such extent that it had little strength and crumbled readily when rubbed.

Apparatus and Methods of Testing.

A test chamber was constructed in which humidity and temperature could be controlled. It was divided into three sections, the top portion containing refrigerating coils over which the incoming air was passed for removal of excess moisture by condensation. The air was then drawn down a metal duct across electrically heated coils to the bottom section, from which it rose through grated openings in the floor to the middle section, where the tests were conducted.

The materials to be tested were placed in a metal box, 3 by 2 by 2 feet, one side of which had a glass sliding window (Fig. 2). Each end of the box had a circular opening 6 inches in diameter fitted with a 6-inch metal pipe. One pipe containing a damper led to a rotary blower by which the air was exhausted through a metal duct. The other, which was immediately in front of the materials to be tested, opened into the test chamber. The suction of the blower furnished the wind velocity required and was measured with an anemometer at the position of the pad. The relative humidity was measured with a sling psychrometer and controlled within variations of less than 10 per cent relative humidity. The room temperature was maintained between 75 and 85° F.

In the tests with grass, as in the previously reported tests, the cigarette was placed on a grass pad fastened to a wire screen standing at an angle of 45 degrees. In the tests with the various forest floor materials, the cigarette was placed on a horizontal pad of the material with the glow toward the air stream. This was adopted as being most representative of exposure conditions for such materials. It was, however, not possible to obtain consistent results with the grass pad placed in the horizontal position.

*Measuring Forest Fire Danger in Northern Idaho, U. S. Department of Agriculture, Misc. Pub. No. 29, p. 15.

Table 2. Results with Untipped Cigarettes.

Material Exposed	Origin	Wind Velocity Mi./hr.	Relative Humidity Per Cent	Number of Tests	Ignitions Per Cent	Cigarettes and Pads
Northern white pine litter.....	Northeast Experiment Sta., Mass.....	7.5	38-48	9	100	Fast - burning cigarettes on horizontal pads
Hardwood litter.	Bartlett, N. H., Experimental Forest.....	6.2	33	8	100	do
Douglas fir duff	Pacific N. W. Forest, Wash.	7.2	32-38	10	100	do
Western white pine duff.....	Priest River Branch, Idaho	7.0	33-40	10	80	do
Lodge pole pine duff	Priest River Branch, Idaho	7.2	33-38	10	90	do
Spruce flat duff	Gale River Experimental Forest, N. H.	7.0	35-38	10	100	do
Chaparral duff..	San Bernadino Forest Calif.	7.2	25-50	10	90	do
Fir duff.....	Calif. Forest Experiment Sta.....	7.3	32-44	10	70	do
Disintegrating Douglas fir wood	Pacific N. W. Forest, Wash.	7.1	33-36	10	90	do
Average for above nine materials.....		7.1	35	87	91	do
Short leaf pine litter	Southern Forest Exp't Sta., New Orleans...	6.8	38	10	20	do
Hardwood litter.	Bent Creek Experimental Forest, N. C.	4.8	32-38	9	0	do
Long leaf pine litter	Olustee Experimental Forest, Fla.....	7.1	31-39	10	0	do
Long leaf pine litter	Olustee Experimental Forest, Fla.....	3.9	15-20	10	0	do
Slash pine litter	Olustee Experimental Forest, Fla.....	7.1	34-37	10	0	do
Loblolly pine litter	Urania, La.....	7.2	34-40	10	10	do
Pine litter.. ...	Bent Creek Experimental Forest, N. C.	7.2	36-39	10	20	do
Pine litter.....	do	6.1	17-18	10	10	do
Pine litter.....	do	3.6	16-22	10	70	do
Pine litter.....	do	2.6	15-20	10	20	do
White cedar litter	Bog Bass River, State Forest, N. J.....	6.2	52-81	13	85	do
do	do	6.1	14-20	10	100	do
do	do	2.9	16-20	9	100	do
Mature yellow pine duff.....	Calif. Forest Experiment Sta.....	2.5	13-20	9	22	do
do	do	6.2	13-20	10	50	do
Fir duff.....	do	6.2	58-85	21	38	do
Western larch fir duff.....	Priest River, Branch, Idaho	6.6	38-40	10	40	do
do	do	6.5	17-23	10	50	do
Redwood duff....	Calif. Forest Experiment Sta.....	7.2	24-36	10	10	do
Douglas fir duff	Pacific N. W. Forest.	6.2	46-75	18	61	do
do	Pacific N. W. Forest.	6.6	33-37	10	0	Slow - burning cigarette on horizonal pad
Disintegrating Douglas fir wood	Pacific N. W. Forest.	7.0	25-35	10	50	do
Grass.....	Washington, D. C.....	3.3	24-43	50	88	Fast - burning cigarette on pad at 45°*
Grass.....	Washington, D. C.....	3.1	37-41	50	88	Fast - burning cigarette on pad at 45°
Grass.....	Washington, D. C.....	3.2	60-85	20	10	do
Grass.....	Washington, D. C.....	1.5	32-38	10	0	do
Grass.....	Washington, D. C.....	4.5	32-38	10	30	do
Grass.....	Washington, D. C.....	6.2	37-48	10	50	do
Grass.....	Washington, D. C.....	3.2	30-38	20	0	Fast - burning cigarette on horizontal pad
Grass.....	Washington, D. C.....	3.0	37-45	10	0	Slow - burning cigarette on pad at 45°

*Full length cigarette burned to 1¼ inch before placing on pad.

Fig. 2. The test apparatus. Cigarette butt was placed in pad of grass or forest litter in cabinet. The suction of the blower (left) furnished the wind velocity required, which was measured by an anemometer adjacent to the pad.

The criterion for ignition in these tests was actual flaming of the pad. The time that the cigarette butt burned up to ignition was obtained and the length burned at time of ignition was estimated. The length of the lighted cigarette when placed on the pad was 1¼ inches, a little less than one-half the length of the usual cigarette.

Results with Untipped Cigarettes.

Table 2 gives the results of tests with untipped cigarettes on forest materials and grass under various conditions of wind velocity and air humidity.

The results with nine forest floor materials, which gave 70 per cent ignitions or more at 25 to 50 per cent relative humidity and 6 to 7½ miles per hour wind velocity, are averaged for comparison with results obtained in tests with tipped cigarettes. Ignitions were obtained in 91 per cent of 87 tests with fast-burning cigarette brands. When the relative humidity was decreased the per cent of ignitions for some of the lower-hazard materials increased slightly. The wind velocity most favorable for ignition was apparently in the range 6 to 7½ miles per hour, as measured a few inches above the pad. The actual velocity at the surface of the pad was probably considerably lower.

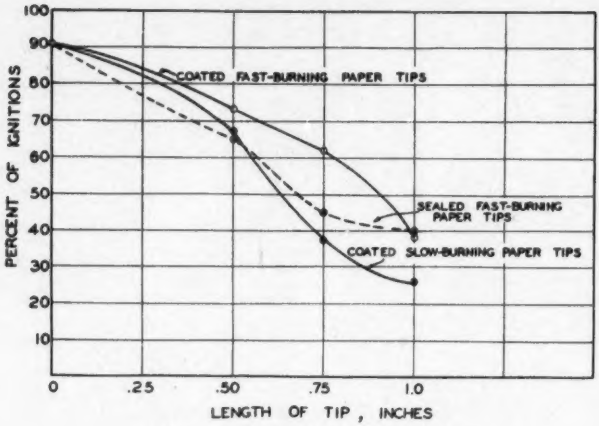


Fig. 3. Effect of length of cigarette tip.

The disintegrating wood ignited quite easily when powdered and even the mild exposure to the glowing portion of a slow-burning cigarette gave 50 per cent ignitions, where no ignitions were obtained with Douglas fir duff or with grass.

The results of the tests with untipped cigarettes showed that there was no discernible difference in the fire hazard of the various makes with the exception of the one slow-burning variety. The results with the individual fast-burning varieties are accordingly not segregated.

The tests with grass gave a high percentage of ignitions for the lower relative humidities and wind velocity between 3 and 4 miles per hour, the latter being measured at the level of the center of the pad. The percentage of ignitions decreased with increase in relative humidity to above 60 per cent and with increase or decrease in wind velocity. The latter confirmed results of the previous tests referred to above. There was little difference in results when the full length cigarettes were lighted and allowed to burn to 1¼-inch length before being placed on the pad and when they were cut to half length and applied.

Tests with Tipped Cigarettes.

As stated above, only the forest floor materials which gave a high percentage ignition in tests with untipped cigarettes (the first nine listed in Table 2) were used in tests with tipped cigarettes. The tips were made of cigarette paper, applied to fast-burning cigarettes by hand. Some tests were made with commercially tipped cigarettes. The tests with the tipped cigarettes on a given forest floor material were made soon after the comparable tests

Table 3. Results with Tipped Cigarettes.

	Length of of Tip In.	Average Length Burned Total In.	Average Length Burned Tip In.	Time to Ignition, Average Min.	Number of Tests	Ignitions Per Cent
(*a*) Starch paste-sealed fast-burning paper tips	.50	.89	.14	4.6	20	65
	.75	.76	.26	3.3	20	45
	1.00	.50	.25	3.3	40	40
(*b*) Starch paste-coated fast-burning paper tips	.50	1.03	.28	8.3	30	73
	.75	.82	.32	5.9	40	62
	1.00	.61	.36	5.4	40	38
(*c*) Starch paste-coated slow-burning paper tips	.50	.97	.22	5.1	60	67
	.75	.81	.31	5.8	49	37
	1.00	.48	.23	4.0	70	26
(*d*) Commercial cork-tipped	.50	.68	0	3.6	10	90
(*e*) Commercial glazed paper-tipped	.50	1.18	.43	9.9	10	80

with the untipped cigarette and the same general range in relative humidity, temperature, and velocity of air currents over the specimen were maintained. The results of the tests are given in Table 3 and Figure 3. The portion of the length of the cigarette that burned decreased as the length of tip was increased. In some tests flaming occurred within 25 seconds and in others 35 minutes were required. In some cases, before the glow in the cigarette was extinguished by the tip, it started glow in the pad, which later resulted in flame.

The proportion of ignitions is seen to decrease from 91 per cent with no tip to about 40 per cent with a one-inch tip of fast-burning cigarette paper. With the slow-burning cigarette paper tip 26 per cent ignitions were obtained. The starch paste used seems to have little effect on the retarding action of the tip, to judge from the comparison of results with sealed and coated tips. The commercial cork-tipped cigarette gave 90 per cent ignitions and the glazed paper-tipped, 80 per cent ignitions. This can be taken as comparable with what was obtained with one-half-inch tips of cigarette paper, considering possible effects of differences in materials on which the burning cigarettes were placed and the relatively few tests on which the results with the commercial tipped cigarettes are based.

Summary.

The results with the untipped cigarettes of the kind that continues to burn after being lighted, indicate that fires may be caused by them when discarded on combustible materials. Placed on grass and forest floor materials, a draft was found necessary to produce flaming ignition. As determined at the level of the exposed material placed with its surface in an inclined position, and with the air current impinging thereon at an angle of 45 degrees, the range in air velocity most favorable for ignition was from 3 to 4 miles per

hour. With the surface of the materials in a horizontal position and the speed of horizontal air currents measured a few inches above the materials, the range for which the highest percentage of ignitions obtained with most of the materials was from 6 to 7½ miles per hour. The air speed at the surface of the exposed materials would be expected to be considerably lower.

Under the conditions of the test, with the most favorable drafts and with relative humidities in the range 25 to 50 per cent, fires were caused on the average by nine out of ten lighted half-length, untipped, fast-burning cigarettes discarded on grass, forest litter, or duff. The percentage of cases resulting in fires increased somewhat with decrease in relative humidity.

The fire hazard of the slow-burning type of cigarette, in which the glow will not progress appreciably after it is discarded, was found to be much lower than for those of the type that, under similar conditions, continue to glow until fully consumed.

The fire hazard of discarded lighted cigarettes can be decreased by applying tips of cigarette paper. In tests with half-length fast-burning cigarettes having tips one inch long of paper similar to that used on this type of cigarette, four fires occurred on the average for every ten trials. With tips of the same length made of the paper used on slow-burning cigarettes, the occurrence of fire in the exposed materials was reduced to one out of four trials.

The placing of tips on cigarettes is practical from the manufacturing standpoint and if made of cigarette paper, they apparently introduce little cause for objection on the part of the user.

Acknowledgment is due to E. N. Munns, Chief of the Division of Silvics of the U. S. Department of Agriculture, for assistance in supplying the forest floor materials used in these tests.

Gasoline Absorption Plant Fire.

Long Beach, California.

An explosion followed by fire was responsible for the loss of nine lives and caused a property loss estimated in excess of $500,000 at the Meader Gasoline Absorption and Compressor Plant of the Signal Hill Gasoline Company at Long Beach, California, on June 2, 1933. The rupture of a casinghead gasoline storage tank was responsible for the disaster.

Property Involved.

The plant involved in the fire was of all-steel construction, except two redwood cooling towers, and was built in 1928. The absorption unit was remodeled and stabilizer and compressor units were added in 1931, thus making it one of the most modern plants in California. The plant had been in continuous operation for four and a half years without accident.

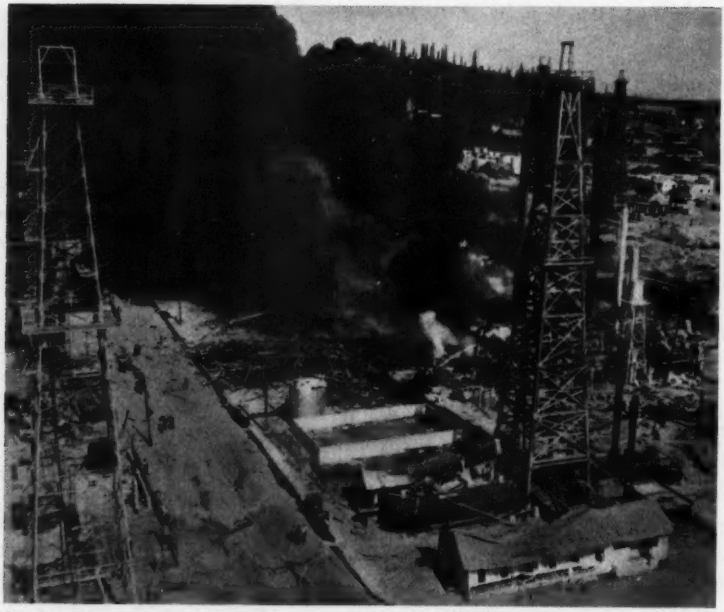
The buildings, principally of corrugated iron on steel frame with concrete floors, consisted of a boiler house, two compressor houses, an oil and gasoline pump house and a small office. Outside equipment consisted of all-steel scrubbers, a steam still, absorbers, exchangers, a large cooling tower for the absorption plant and a small cooling tower for the compressor plant. The six gasoline storage tanks were of riveted and welded steel and the two absorption oil tanks were of bolted steel construction. These tanks were surrounded by a reinforced concrete wall five feet high.

The plant was located adjacent to a congested section of the Long Beach oil field on one side and to a residential section on the other side. This location was nearly on the boundary between the City of Long Beach and the City of Signal Hill, and is under practically full fire protection of both cities. Private fire protection at the plant consisted of two portable dry powder foam generators, 5200 pounds of dry chemicals, one 250 G.P.M. fire pump, hydrant and hose, 2½ and 40-gallon foam extinguishers and a boiler fire snuffing system with manual control valves located at strategic points in the plant yard. Due to the suddenness and violence of the explosion, the fire fighting equipment was rendered inoperative.

Story of the Fire.

At approximately 2:00 P.M. on Friday, June 2, 1933, an explosion occurred, followed in about 36 seconds by a second and more violent explosion, the initial explosion resulting from the failure of one of the gasoline storage

This report has been prepared largely from data furnished by Mr. Lloyd Griffith (Member N.F.P.A.), Chief Petroleum Surveyor, Board of Fire Underwriters of the Pacific, supplemented by information contained in the official verdict of the coroner's jury as published in the *Long Beach Sun*, June 8, 1933.



Acme.

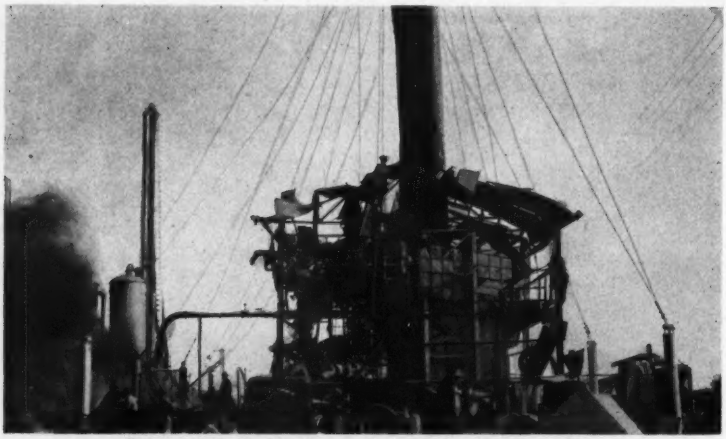
Airplane view of burning gasoline absorption plant at Long Beach, Calif., June 2, 1933. This plant, located on the edge of a heavily congested town-lot drilling section, was surrounded by derricks, crude oil tanks and numerous small dwellings occupied by oil workers.

The above picture indicates the downward force of the explosion on houses and shacks in the vicinity of the plant. Note the damming of oil and water to prevent further damage.

Street on the north side of the plant, showing derricks and other equipment demolished by the explosion.

View of blazing ruins of gasoline absorption plant. In the center background may be seen the gap in the concrete wall through which a horizontal gasoline tank was blown by the force of the explosion, landing 150 feet away.

tanks. The heavy diffusion of the vapors released in the initial explosion furnished a combustible mixture in the atmosphere in the vicinity of the plant, which when ignited resulted in the second destructive explosion. While the source of ignition responsible for this second explosion is not, and probably will not ever be definitely known, there were a number of possible sources such as the exhausts of the compressor plant located on the premises, and open fire box boilers in surrounding properties. The force of the explosion



Ruins of the boiler house stripped by the explosion.

completely wrecked the gasoline plant, derricks and equipment, and near-by houses and buildings. Structures within the radius of several blocks also sustained considerable damage. The ensuing fire ignited tanks of crude oil and destroyed a number of derricks and equipment in the immediate vicinity. Alarms were sent at once to Signal Hill, Long Beach, Wilmington and Los Angeles and twenty pieces of fire apparatus answered in a short time. The fire was fought with foam and water by these fire departments and by fire crews and equipment from the various oil companies operating at Signal Hill and was under full control by 6:00 P.M.

The greatest property loss occasioned by the explosion and fire was suffered by the Signal Hill plant, which was valued at approximately $250,000. The boilers, heavy towers and possibly many of the compressors will have some salvage value, however. Derricks and tanks in the vicinity, property of various producers, were damaged by both the explosion and resultant fire. Approximately fifty small residences, offices and stores scattered through the neighborhood were also damaged in varying degrees.

Nine persons lost their lives as a result of this disaster, five of whom were employees of the Signal Hill Gasolne Company. Of the other four, two were employees of other oil companies and two were occupants of a near-by dwelling.

Verdict of Coroner's Jury.

An inquest was held by a coroner's jury, which returned a verdict on June 7 after two hours' deliberation. The verdict of the jury is as follows:

"We believe that the explosion and subsequent fire were the results of the initial failure of a horizontal steel storage tank of unstabilized casinghead gasoline, known as

tank No 4, and that this failure was due to overfilling said tank, thereby releasing its contents, which contents were subsequently ignited, causing the major explosion.

"We believe that the overfilling of storage tank No. 4 was the result of an operating error coincident with a condition of unusual shortage of storage capacity for unstabilized gasoline occasioned by a shutdown for repairs of the stabilizing equipment during the previous twenty-four hours prior to 10:30 A.M. of the day of the explosion.

"In view of the testimony submitted to the jury and the widespread effects of this catastrophe, involving great loss of life and property, the jury recommends that the Industrial Accident Commission undertake without delay the supervision of the construction and operation of unfired pressure vessels particularly in the oil and other industries handling or treating inflammable material, as the testimony brought out clearly established the fact that no such supervision has been exercised by any official department of State or Government."

Westwego, La., Alcohol Tank Fire.

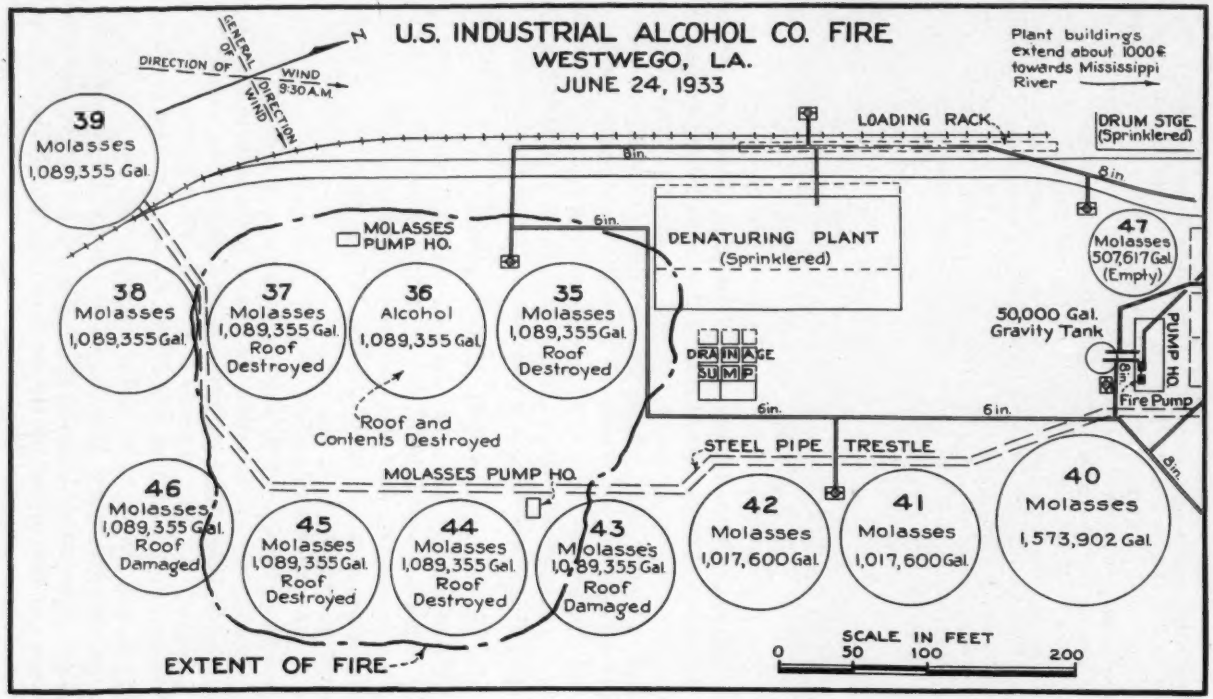
Report by S. G. Peters, Engineer,
Louisiana Rating and Fire Prevention Bureau (Member N.F.P.A.).

A spectacular fire, originating in a million-gallon alcohol tank, destroyed the tank and its contents and badly damaged several adjoining molasses tanks at the plant of the U. S. Industrial Alcohol Company, Westwego, Louisiana, on June 24, 1933. The cause of the fire was lightning. This fire demonstrated clearly the undesirability of using for flammable liquids, tanks not designed for this purpose. The necessity for gas-tight roofs for tanks containing flammable liquids and the ineffectiveness of ordinary foam as an extinguishing agent for alcohol fires were also emphasized.

Description of the Property.

The property involved in the fire consisted of a group of storage tanks which formed part of an alcohol distillery and denaturing plant. The plant buildings were, for the most part, of frame or frame metal-clad construction, ranging from one to five stories in height. Two buildings were of non-combustible construction.

Thirteen storage tanks (Nos. 35 to 47 inclusive), ordinarily used for the storage of molasses, and having a capacity from a half million to a million and a half gallons each, were located in the yard adjacent to the denaturing building. These tanks were of steel construction, resting directly on the ground. All tanks had roofs of wood sheathing on wood rafters and were covered with metal and composition roofing. A wooden cupola (provided with wire screen) at the peak of the roof served as a vent. The tanks were not protected against lightning. At the time of the fire, tank No. 36 contained approximately 1,000,000 gallons of denatured alcohol. The remaining tanks contained molasses except No. 47, which was empty.


U.S. INDUSTRIAL ALCOHOL CO. FIRE
WESTWEGO, LA.
JUNE 24, 1933
Plant buildings extend about 1000 ft towards Mississippi River
N
GENERAL DIRECTION OF WIND 9:30 A.M.
DIRECTION WIND
39 Molasses 1,089,355 Gal.
LOADING RACK
DRUM STGE. (Sprinklered)
8in.
6in.
MOLASSES PUMP HO.
DENATURING PLANT (Sprinklered)
47 Molasses 507,617 Gal. (Empty)
38 Molasses 1,089,355 Gal.
37 Molasses 1,089,355 Gal. Roof Destroyed
36 Alcohol 1,089,355 Gal.
35 Molasses 1,089,355 Gal. Roof Destroyed
50,000 Gal. Gravity Tank
DRAINAGE SUMP
PUMP HO.
Fire Pump
Roof and Contents Destroyed
STEEL PIPE TRESTLE
MOLASSES PUMP HO.
46 Molasses 1,089,355 Gal. Roof Damaged
45 Molasses 1,089,355 Gal. Roof Destroyed
44 Molasses 1,089,355 Gal. Roof Destroyed
43 Molasses 1,089,355 Gal. Roof Damaged
42 Molasses 1,017,600 Gal.
41 Molasses 1,017,600 Gal.
40 Molasses 1,573,902 Gal.
EXTENT OF FIRE
SCALE IN FEET
0 50 100 200

New Orleans Item Tribune.

Airplane view of plant of Industrial Alcohol Co., Westwego, La., showing burning alcohol tank. Note congestion of plant property and fire spreading to roofs of other tanks in the vicinity.

Private Fire Protection.

All major buildings of the plant were equipped with a wet pipe automatic sprinkler system. Eleven two-way hydrants fed by 6- and 8-inch water mains on a loop system constituted private outside protection. Both sprinklers and hydrants had as a primary supply an 8-inch connection from an 8-inch city main, with a 50,000-gallon gravity tank as a secondary supply and a 1000 G.P.M. steam fire pump taking suction from three above-ground interconnected steel tanks of 131,000 gallons capacity each, as a third supply. Three 1000 G.P.M. trade pumps connected into fire mains were also available for fire fighting purposes.

A ditch from which two pumpers took suction was about 3 feet deep and 2 feet wide and was supplied with water from overflowing a well reservoir about 150 feet from where the pumpers were stationed. This reservoir was supplied by two deep well pumps, one of 800 G.P.M. capacity and the other of 1000 G.P.M., furnishing plenty of water for the pumpers.

Story of the Fire.

The fire occurred at about 9:17 A.M. on June 24, 1933, during a thunder shower. There was a sharp flash of lightning, immediately following which the alcohol in tank No. 36 burst into flames. The exact cause of ignition is

New Orleans Item Tribune.

View of burning alcohol, looking north from the roof of tank No. 38, across tank No. 37.

not known, although the start of the fire was observed by a man on the roof of a near-by tank, No. 43. It may have been a local discharge between the metal on the wood roof and the steel sides of the tank or between objects adjacent to the tank. It may have been a direct discharge to the roof of the tank.

Plant employees, twenty-one in number, were immediately summoned, hose lines were run out from plant hydrant, and the fire pump was started. The Westwego fire department was called at 9:20 A.M. and a pumper and hose truck responded promptly. Pumpers from four other near-by communities also responded to calls for assistance and arrived at intervals up to 9:50 A.M. Two of these pumpers took suction from the private hydrants at the plant, one took suction from a ditch near the pump house and two took suction from hydrants of the city water system on the highway southwest of the property. The pumpers ranged in capacity from 250 G.P.M. to 600 G.P.M. and of the hose lines employed at least four exceeded 900 feet in length. At 12 o'clock noon a 750 G.P.M. pumper from New Orleans arrived and took suction from the ditch near the pump house, supplying a single 600-foot line. There were from eleven to twelve good hose streams in use during the fire.

By the time the firemen arrived, flames were leaping into the air 50 to 75 feet above the top of the tank, and realizing the futility of attacking the burning alcohol tank with water they directed their efforts to protecting surrounding property. The wind at this time was from the southwest, carrying the heat and flame toward the denaturing building, which, among other contents, contained forty-five 100-gallon drums of ether, one hundred and fifty 50-gallon drums of denatured alcohol and 30,000 to 40,000 gallons of alcohol in mixing tanks. Hose streams were directed on the roof and exposed walls of this building and twenty-five heads on the sprinkler lines in the exposed end of the building were opened by an employee who knocked out the fusible links. Drums of alcohol and ether were removed from the ground floor, but it was not deemed feasible to remove those on the uppper floor.

When the wind shifted to the west the flames were carried toward tanks Nos. 44 and 45 and the roofs of these tanks ignited from time to time, but up until late in the day these incipient fires were extinguished by prompt application of hose streams. Meanwhile the fire continued to burn with intensity, and with another shift in the wind there was a possibility that the entire plant might become involved. At this point consideration was given to the advisability of pumping the alcohol from the burning tank to another tank (No. 47 of 500,000 gallons capacity), located some distance away. Due to the close proximity of this latter tank to other plant property, its unsuitability for alcohol storage and the possibility of the ignition of escaping vapors, the idea was abandoned as too great a risk.

With no safe place on the premises to pump the alcohol for salvage purposes, an attempt was made to extinguish the flames by use of foam. Three foam generators were connected to some equipment hastily assembled and foam was applied for about twenty minutes with 9700 pounds of foam powder being used. The foam seemed to force the seat of the fire toward the side of the tank opposite which application was being made, but the alcohol dissolved the foam so rapidly that the foam blanket could not be sustained long enough to have any effect in extinguishing the burning liquid.

The roofs of tanks Nos. 44 and 45, which had not burned up to this time, ignited and were destroyed. The fumes and smoke from the burning molasses and the intense heat greatly hampered the firemen, who directed their hose streams on the fire from behind improvised shields. The firemen, with the exception of the companies from Algiers and New Orleans, were practically all volunteers, and their work in face of the difficulties encountered is to be commended.

With the alcohol diluted and discolored by water and foam and still furiously burning, it became evident that there would be very little salvage. Therefore, in view of the potential danger to the plant it was decided to pump alcohol from the tank into the Mississippi River until water from hose streams played into the tank diluted the alcohol remaining to a point where it would no longer burn. This was accomplished by use of a molasses pump and a connection from the tank to the molasses line.

In this way approximately 25,000 gallons of alcohol were pumped into the river from 5:30 to 8:30 P.M. At that time it was thought that it would be a matter of only an hour or so until the fire burned out, and in order to hasten dilution two hose lines were stretched directly from the fire pump and connected to the molasses line (the same line through which alcohol was pumped into the river) in the pump house. Water was pumped through this line into the tank and the fire was finally extinguished at 6 A.M. on June 25.

Extent of Damage.

Tank No. 36 and the entire contents are said to be a total loss. About 600,000 gallons of alcohol and water remained in the tank when the fire was extinguished, but the alcoholic content was estimated to be only from 12 to 15%. The roofs on molasses tanks Nos. 35, 37, 44 and 45 were destroyed, and the roofs on tanks Nos. 43 and 46 were damaged. Steel pipe trestles and pipe lines were damaged by heat. Four million gallons of molasses were damaged, with about 10% loss.

Wood barrels, steel drums and driving belts and motor were damaged in the Denaturing Plant and 7300 gallons of pure alcohol diluted. The molasses pump house, other minor outhouses and equipment were damaged or destroyed. The total loss was estimated at $360,000.

Fire Record of Country Clubs

Since the establishment of the first golf club in the United States more than forty years ago (St. Andrews, New York, 1888), the number of golf and country clubs in the United States and Canada has increased to approximately 4500, according to statistics published in the *American Annual Golf Guide*, edition 1930-31. The trend toward more leisure time under our present day economic order, coupled with a greater interest in golf on the part of the general public, bids fair to bring about an even greater increase in the number of golf and country clubs in the future.

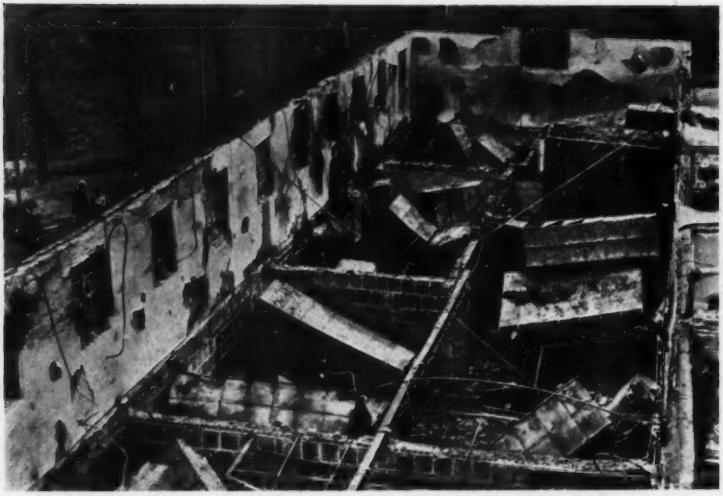
The fire record of golf and country clubs has not been enviable. By virtue of their character country club houses are usually located beyond city limits, and often distant from adequate public fire protection. Private protection is frequently woefully inadequate or entirely lacking. Frame construction predominates, with wide piazzas and numerous windows and doors affording ample opportunity for drafts. Moreover, the architectural design of country club buildings with spacious rooms, wide corridors and stairways without cut-offs of any sort usually offers little resistance to the rapid spread of fire to all parts of the building. Combustible trim and furnishing contribute freely to the intensity of the fire.

Incomplete statistics recently compiled indicate that during the fifteen-year period from 1918 to 1932 inclusive there have been a total of 93 fires in country clubs which have involved individual losses of $10,000 or more. These fires have been responsible for a total reported loss of $5,841,468.

The files of the Department of Fire Record of the National Fire Protection Association contain reports on one hundred and forty-seven country club fires, all but twelve of which have occurred since 1916. The record is by no means complete and does not include many of the small fires which have occurred from time to time in country club property. Insurance inspection bureau reports are the source of data on a considerable number of country club fires, supplemented by reports based on newspaper accounts which have been verified through the coöperation of N.F.P.A. members.

In view of the character of the original data, which include the larger and more important fires, but not a fair proportion of the smaller fires, this record may not be completely representative. The record, however, includes a sufficiently broad selection of the important country club fires, so that there can be no question as to the validity of conclusions drawn in the tables here.

Most of the buildings involved in the fires covered by this record were of wood and practically all had wooden interior construction. A considerable number had wooden shingle roofs which, as indicated by a subsequent table, were directly responsible for approximately 13% of all the fires recorded.



Masonry and steel alone do not make a "fireproof" building. This picture shows the ruins of the Brook Lea Country Club, near Rochester, N. Y., that burned in 1926 with a loss reported at $65,000.

Country Club Fires—Construction of Buildings.

	No. Fires
Frame	103
Stucco on frame	7
Brick veneer	2
Brick or stone and frame	6
Brick, stone or concrete block—joisted	9
Semi-fire-resistive	2
Fire-resistive	1
No data as to construction	17
Total	147

The complete destruction of many of the buildings in these fires may undoubtedly be charged to combustible construction even though not so specifically stated in the original reports. The combustible wooden interiors, basements not cut off, stairways unenclosed, absence of proper fire stops, all contributed to the spread of fire. These fires were difficult to control, even when an efficient fire fighting force and adequate water supplies were available.

Two fires occurred in buildings of semi-fire-resistive construction and one in a fire-resistive building. Due to lack of proper protection for steel members in one instance and the presence of a wooden stairway and combustible roof structure in a building of otherwise fire-resistive construction in the other instance, large losses were involved in two of these fires. Details regarding these fires will be found elsewhere in this record.

International.

The greatest number of country club fires occur at night. The above picture shows the burning of the Quebec, P. Q., Golf Club on June 8, 1929.

How the Fire Was Discovered.

	No. Fires
Employees	66
Outsiders	28
Members or guests	10
Watchman alone	8
Watchman and sprinkler alarm	1
Sprinkler alarm alone	7
Sprinkler alarm and employee	1
No data as to manner of discovery	26
Total	147

Nine fires were discovered by watchmen, all of which occurred after eight o'clock in the evening and prior to seven o'clock the next morning. Six of these involved partial losses, less than 25 per cent of the values involved. Three involved total losses—one by reason of inadequate water supplies, one due to the headway of the fire when discovered and the construction of the building which permitted rapid spread of the flames through concealed spaces, and one due to absence of any adequate fire protection whatever.

The fire recorded as discovered by the watchman and sprinkler alarm was first seen by the watchman, who went for a fire extinguisher. The sprinkler alarm sounded and a sprinkler operated before he could use the extinguisher.

Sprinkler alarms alone were the first notification of fire in seven instances, while in two instances (one recorded above and one other) the watchman or an employee discovered the fire simultaneously with the sprinkler alarm. Sprinkler alarms operated in six other fires but in these cases were not a primary factor in its discovery. Additional details of the operation of sprinkler alarms will be found in "Fire Record of Sprinklered Country Clubs."

The greatest number of fires in country club property for which the time of origin has been ascertained occurred between the hours of 7 P.M.

and 7 A.M. Seventy-seven fires occurred during this period, the most frequent hours being 7 to 8 P.M., 2 to 3 A.M. and 4 to 5 A.M. Fifty-five fires occurred during daylight hours, the largest number from 12 to 1 P.M. and 4 to 5 P.M. Reports on fifteen fires failed to indicate the exact time of origin.

Causes of Country Club Fires.

	No. Fires	Per Cent of Known Causes
Stoves, furnaces, boilers or their pipes	29	25.6
Electrical causes	20	17.7
Smoking—matches	18	15.9
Sparks on wooden shingle roofs	15	13.3
Ignition of rubbish or litter	6	5.4
Ignition of grease on stove or in ventilator	5	4.4
Spontaneous ignition—oily material	4	3.5
Sparks from open fireplace	3	2.7
Lightning	3	2.7
Incendiary	2	1.7
Hot ashes	2	1.7
Other known causes	6	5.4
Total Known Causes	113	100.0
Unknown causes	34	
	147	

The foregoing table of fire causes indicates clearly that country clubs are similar to hotels in potential fire hazards and those causes responsible for fires in the latter class (see N.F.P.A. pamphlet "Hotel Fires") also predominate in this class of occupancy. Practically all fires in country club property have been due to common hazard causes. Seven items are responsible for 97 out of the 147 fires listed in the N.F.P.A. fire record, or 86% of the fires for which the cause has been reasonably ascertained.

Stove, furnaces, boilers and their pipes lead the list of fire causes, with 29 fires attributed to defects therein or overheating. The fires reported as overheated furnaces, boilers, stoves, or flues are presumably due in most instances to some sub-standard feature of design or installation. An analysis of this group is as follows:

	No. Fires
Defective chimneys or flues	12
Overheated furnace or boiler	4
Woodwork under stove or range ignited	4
Overheated chimneys or flues	3
Overheated stove or range	2
Oil stove "explosion"	1
Oil burner "explosion"	1
Started around stove—exact cause unknown	2
Total	29

Electrical causes were responsible for 20 fires. "Defective wiring" as a fire cause is always open to question, and it is, of course, possible that in a number of fires in this record to which this cause was assigned there may be some doubt as to the actual cause. On the other hand, some of those fires listed as of unknown origin were recorded on original reports as "Unknown —possibly defective electric wiring".

The careless disposition of lighted cigarettes and matches accounted for 18 fires. Such fires in a club house are difficult to prevent and the most of these fires may be attributed to the careless tossing of cigarettes or matches into combustible material or on to carpets or rugs.

The number of fires on wooden roofs from chimney sparks confirms the already existing evidence that wood shingles are unsuited to use as a roof covering. Many of these fires were in country clubs located beyond city limits or in small towns, where a lack of fire protection allowed the complete destruction of the building.

Grease collecting in the ventilating pipes, connected with the kitchen ranges used in country clubs, has frequently caused fire. This grease condenses on the inside of the pipes in a thick coating which may ignite and communicate to near-by combustible material. Such fires are difficult to cope with and are liable to spread rapidly beyond control. Obviously, it is best to forestall fire by frequent cleaning of the ventilators. Many of these fires are extinguished with small loss and are not reported.

Miscellaneous known causes account for six fires, as follows:

Defective construction—wood beams imbedded in chimney	3
Exposure	1
Explosion—fireworks	1
Gas explosion	1

The table which follows shows the point of origin of fires which have occurred in country clubs included in the record. It is indicative of the locations to which protection need first be applied.

Point of Origin of Country Club Fires.

	No. Fires		No. Fires
Kitchen	17	Partitions	7
Roof	16	Attic or roof space	6
Living rooms	14	Sleeping rooms	6
Heater or boiler room	13	Other known places	9
Locker rooms or lavatory	13	No data	27
Basement	11		
Repair shops, storerooms, etc.	8	Total	147

The following analysis of the losses reported shows how large a proportion of the fires in this record were severe losses. This may be due partly to the fact that the N.F.P.A. Department of Fire Record does not receive reports on many inconsequential fires.

P and A Photo.

The New Haven, Conn., Lawn Club fire of September 21, 1929. Large loss daytime fires may occur in country clubs, even though under city fire protection, when construction is such as to permit rapid spread of fire.

Analysis of Loss—County Club Fires.

	No.	Per Cent	Aggregate Loss
Loss under $1,000	22	17.6	$5,103
Loss $1,000 to $10,000	20	16.0	121,260
Loss $10,001 to $50,000	45	36.0	1,461,100
Loss $50,001 to $100,000	27	21.6	2,166,590
Loss over $100,000	11	8.8	2,047,350
Total fires—Known loss	125	100.0	$5,801,403
Slight loss	10		
Moderate loss	1		
Considerable loss	3		
Large loss—total	8		
Total fires	147		

From the foregoing table it appears that of the 147 fires included in this fire record ninety-one occasioned individual losses in excess of $10,000. To determine the factors that have been responsible for making these ninety-one fires large loss fires, an analysis has been made of the reports of these fires. Obviously not all large losses can be attributed to a single factor and in some instances several factors have been equally responsible for the rapid spread of, and consequent large damage by the fire. Such a case was the fire which destroyed a large country club at East Lake, Ga. It is reported that the reasons for this large loss were (1) headway of fire when discovered, (2) inadequate water supply and (3) inferior construction which aided the rapid spread of the fire.

The factors indicated by the individual reports as being responsible for the large losses in country club fires are summarized below. Of the 91 fires

causing individual losses in excess of $10,000, data were not available regarding the reason for the large loss in 20 instances. It is obvious from the totals that in most cases more than a single factor was involved.

The factor most frequently noted as responsible for large loss fires was "inadequate water supplies". This includes all instances where no water supply at all was available and also instances where water was available but either in limited quantities or at unsatisfactory pressures. Where it was necessary for fire departments to take water from a lake or stream at some distance from the burning building with a consequent delay in fighting the fire such a case would be classified as "inadequate water supplies" as well as "fire department delayed in getting to work".

Another principal factor was "headway of fire prior to discovery". The predominance of night time fires over day time fires as discussed previously in this record would seem to be of significance in this connection.

Inferior construction, as might be expected, played its part in making possible the rapid spread of fire throughout the building. Numerous instances might be cited of fires in which lack of cut-offs, no fire stopping, excessive fire areas, unprotected roof spaces and open attics, unprotected steel construction and combustible roof structures have contributed to large losses.

Reasons for Large Loss.		No. of Fires
Inadequate water supplies		47
Water available, but pressure or volume insufficient	29	
No water supply available—first aid protection only	15	
Water pressure weak at start of fire	3	
Headway of fire prior to discovery		20
Ineffective fire fighting		17
Fire department delayed in getting to work	13	
First aid equipment defective or inoperative	2	
Incompetent fire fighting	2	
Inferior construction		11
Delayed alarm		7
No fire protection (public or private) available		6
Strong wind swept exposure fire into building		1

Fire department hose streams were used at 51 of the fires listed in the following table, while hose streams from private water supplies were used at eleven fires. The available water supply was adequate for fire-fighting purposes at 66 fires while, as indicated by a previous table, inadequate water supplies or no water at all were factors in 47 cases. In six fires the water supply was not a factor.

Ninety-two country club fires, or approximately 62% of all the fires in the records, occurred within the jurisdiction of city, town or volunteer fire departments and those departments assisted at their extinguishment. Employees or members were the only fire fighting forces at 26 fires, and sprinklers

alone extinguished eight fires. Six fires occurred where there was no fire protection of any sort and no data were available as to methods of fire fighting in 15 instances.

How Fire Was Fought.

	No. Fires
Hose streams	48
Hose streams and first aid equipment	8
Hose streams and automatic sprinklers	4
First aid equipment alone	19
First aid equipment and sprinklers	7
Sprinklers alone	8
No fire-fighting equipment available	6
No data	47
Total	147

Fire Record of Sprinklered Country Clubs.

This record comprises a total of twenty-seven fires in property protected by standard automatic sprinkler systems and four in property protected by automatic chemical sprinkler equipments. Eleven of these fires were of such character and location that no sprinkler heads operated. In every case where sprinklers were a factor the fires reported involved individual losses of less than $1500.

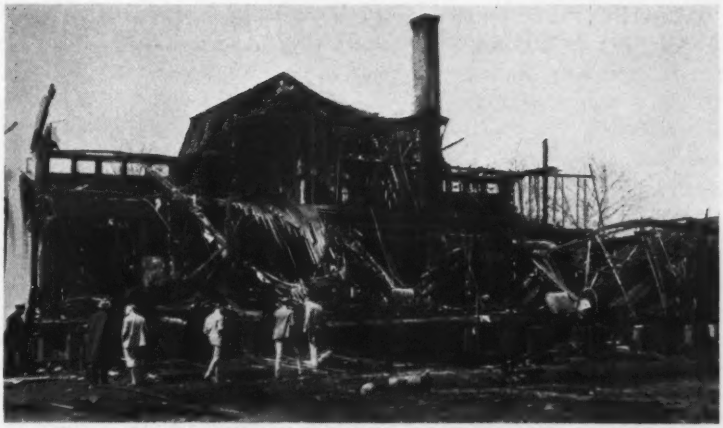
Sprinkler Fire Record.*

	No. Fires
Sprinklers extinguished fire	8
Sprinklers held fire in check	8
Total	16
Sprinklers not a factor	11

Of the sixteen fires in which sprinklers were a factor, all but two were controlled by the operation of three sprinkler heads or less. In one instance where more than three sprinklers operated the fire was on the roof and five sprinklers in the attic operated for about twenty minutes, holding the fire in check in several places where shingles had burned through. In the other instance fire involved Christmas decorations in a large living room, making a very hot quick fire, opening eight sprinkler heads which extinguished the fire. From these data it would appear that country club fire hazards are such that where sprinklers have been a factor their operation has been entirely successful, and fires occurring have been controlled by the operation of a minimum number of heads. Properly installed and maintained, there is no reason to believe that such performance on the part of standard sprinkler systems cannot be maintained and expected.

Of fifteen fires in which sprinkler alarms are reported as having operated, such operation in nine instances was the first notification to occupants of

*Table does not include four fires where chemical sprinkler systems were a factor.



Inadequate water supply is blamed for the destruction of the Elizabeth, N. J., Town and Country Club on April 8, 1925.

the building. In seven instances the sprinkler alarm alone gave the first warning, while in two cases the fires were discovered by employees or watchmen simultaneously with the operation of the alarm. Nine of these fires occurred at night and six during the day. Only two losses exceeded $1000.

Three of the four fires in buildings equipped with chemical sprinkler systems were controlled satisfactorily. Two of these were small fires, one an overheated oil stove and one over a kitchen stove, and the third involved an unoccupied attic. This latter fire acquired considerable headway, but twenty heads on the chemical sprinkler system in the attic operated and held the fire until the arrival of the fire department, which extinguished the remaining blaze with chemical streams. The loss was approximately $4000, but with no water available the loss would have probably been total had it not been for the automatic chemical sprinkler system.

The fourth fire was unsatisfactory primarily due to faulty construction which permitted the fire to work up through concealed spaces in the walls out of reach of sprinklers and involve the second floor and attic.

Typical Fires Where Automatic Sprinklers Operated.

COLUMBUS COUNTRY CLUB, COLUMBUS, GA., APRIL 3, 1929. A fire occurred at 8:45 P.M. from a carelessly thrown cigarette in the office of this two-story wooden frame club house. The sprinkler alarm sounded and employees telephoned the fire department. One sprinkler opened and held the fire in check but did not completely extinguish the fire, which was in a niche in the wall where the water could not reach. Three chemical extinguishers were used by employees and the fire department to put the fire out. (S-50714)

ACACIA COUNTRY CLUB, SOUTH EUCLID, OHIO, Nov. 2, 1930. This fire started at 3 A.M. in a can of rubbish at the foot of the basement stairway. It was confined to the point of origin by the operation of two sprinklers. The night engineer who sleeps at the club was awakened by the sprinkler alarm. He found the two heads operating, shut off the water, replaced the heads and turned on the water before he discovered that there had been a fire. There was no loss. (S-57976)

COLONIE COUNTRY CLUB, COLONIE, N. Y., DEC. 3, 1930. As far as is known this fire was due to defective wiring in the lighting system. The first notification of trouble was when the sprinkler alarm operated. Employees investigated the source of the alarm and found a fire burning in a blind space over an attic bedroom. One sprinkler in the bedroom and two in the blind attic operated and checked the fire, which was confined to a small section after it had burned a small hole through the wooden shingle roof. Employees used four 2½-gallon soda-acid extinguishers and a 1½-inch hose stream to completely extinguish the fire. The loss was moderate, whereas had the building not been sprinklered it is probable that the loss would have been total. (S-56535)

NORTH HEMPSTEAD COUNTRY CLUB, PORT WASHINGTON, N. Y., DEC. 15, 1931. When an explosion occurred at 8:40 P.M. in the fire box of an oil-fired water heater, flames were forced through the chimney flue, igniting the wooden shingle roof. The fire was discovered by the watchman, who found one sprinkler head operating in the attic under the roof. The fire department was called and extinguished the fire with two hose streams from a private yard hydrant recently installed on the premises.

In the meantime five sprinkler heads in the attic operated for about fifteen to twenty minutes, holding the fire in check in several places where the shingles had burned through. Although some fire damage was done to the roof no fire entered the building. The loss was $3100. (S-60133)

BALTUSROL GOLF CLUB, BALTUSROL, N. J., DEC. 12, 1932. A short circuit in a radio set was responsible for this fire. An employee passing through the hallway noticed smoke and traced it to a sleeping room. Upon opening the door the radio set was seen to be in flames and just at that time a sprinkler head operated. The operation of the sprinkler entirely extinguished the fire which otherwise might have resulted in a heavy loss. The loss was $140. (S-63043)

Automatic Chemical Sprinkler Systems.

BIRMINGHAM COUNTRY CLUB, BIRMINGHAM, ALA., JULY 3, 1929. Due to the fact that it started in an unoccupied attic over the ballroom and lounge rooms and near electric wiring, it is reasonable to assume that defective wiring was responsible for this fire. The building was of fairly good construction, having exterior walls of sandstone and an interior of part fire-

The Birmingham, Ala., Country Club, where fire started in an attic from defective wiring. There was no public water supply, and had the fire not been checked in its incipiency by the prompt operation of automatic sprinklers it would have been impossible to fight it successfully.

resistive and part ordinary joisted construction. The first notification of the fire was at 11:45 P.M. when the sprinkler alarm operated.

The automatic chemical sprinkler system operated and twenty heads in the attic opened, using two 200-gallon soda-acid chemical tanks as a supply. These sprinklers held the fire in check until the arrival of the fire department which, using chemical tanks, finally extinguished the fire. The loss was estimated at $4,000.

It is probable that this fire would have resulted in a total loss had it not been for the automatic sprinkler system which held the fire in check until the arrival of the fire department. There was no public water supply available and had the fire not been checked in its incipiency, it would have gained such headway that it would have been impossible to fight it successfully. (SE-17)

Loss of Life in Country Club Fires.

In compiling the fire record of country clubs there were found to be five fires in which loss of life occurred. Seven of those who lost their lives were members or guests, one was an employee and one a bystander. A brief summary of the fires involving loss of life follows.

SAN ANTONIO COUNTRY CLUB, SAN ANTONIO, TEX., MARCH 26, 1916. Three men and two women guests lost their lives when a fire, charged to the spontaneous ignition of oily rags and painter's materials, swept the club house at 2:55 A.M. The fire, originating at the foot of a wooden stairway leading from the basement, spread rapidly to the floors above and soon enveloped the entire structure which was of combustible frame construction throughout. A strong wind prevailing at the time of the fire coupled with a long continued drouth was a factor in its rapid spread. Although under city fire protection the building was completely destroyed, with a loss of $34,500. (H-11657)

LAFAYETTE CLUB, MINNETONKA BEACH, MINN., JUNE 18, 1922. Discovered by a passing motorist who noticed the reflection of flames on the window panes of the dance hall, a fire swept through the rambling club house so rapidly that within twenty-five minutes the entire structure was a mass of flames. The fire occurred shortly before 2 A.M. The thirty-two guests and forty employees who were in the building were aroused in time and all but two made their escape in safety, although scantily clad and without opportunity to save any of their personal effects. Two guests, both women, lost their lives when they returned to their rooms to save some of their belongings. Fire fighting facilities were not immediately available and by the time firemen from adjoining communities reached the scene they were too late to be of any service. The property loss was estimated at more than $100,000. (H-18713)

PHILADELPHIA RIFLE CLUB, PHILADELPHIA, PA., FEB. 28, 1923. This building was of brick-joisted construction, three stories high, used as a club house, with attendants living on the premises. The fire was discovered at 3:55 A.M. by occupants who, with one exception, escaped with difficulty. The fire department was called, but as the building was located in a suburban district and isolated, the fire had assumed considerable headway before their arrival and was not extinguished until the structure and contents were destroyed.

An employee of the club, the steward, was trapped in the burning building and was burned to death. (H-19352)

CLAIRMONT COUNTRY CLUB, OAKLAND, CAL., JAN. 23, 1927. One man was burned to death and eight persons were rescued by firemen when fire swept this large 3-story frame residence which had been converted into a club house. The fire occurred at 1:07 A.M. at which time there were five guests and three employees in the building, in addition to the watchman who lost his life. The motive that prompted the watchman to re-enter the building was evidently to awaken and save guests and fellow employees. He was trapped in this attempt and burned to death.

The fire had its origin above the kitchen between the first and second floors adjacent to a chimney. Previous fires in this building had originated at about the same location. This chimney had timbers built into it at the various floors, and this feature, or a defect in electrical wiring which (both old and new) filled this space, may have accounted for the origin of the fire. The loss was estimated at $203,767. The fire was fought by the city fire department with hose streams from six motor pumpers. (H-24257)

STONERIDGE COUNTRY CLUB, STONINGTON, CT., AUG. 16, 1933. A spectator, who had been assisting other volunteers in keeping the crowd at a safe distance, was fatally injured by a brick flying from a falling chimney during the destruction of the club house by fire shortly after 8 P.M. The fire

was due to a defective chimney which resulted in the ignition of the wooden shingle roof. With but meagre fire fighting equipment available, the roof was soon completely involved and then the fire worked its way slowly downward through the building. The building, valued at $60,000, was a total loss due to the lack of water supply available for fire department use. The two volunteer fire departments which responded used chemicals to keep the club garage from burning. (H-37029)

Typical Country Club Fires.

The following brief summaries of typical country club fires have been selected as indicating some of the factors that have been responsible for such fires and a reason for large loss. A number of fires typical of effective use of first aid equipment are also included.

Delayed Alarm.

YOUNGSTOWN COUNTRY CLUB, YOUNGSTOWN, OHIO, MAY 2, 1928. The building involved in this fire was a three-story frame structure with basement, having wings at either side of a central section cut off by fire walls. Openings in these walls were not protected.

A short time after midnight, an employee noticed smoke coming through the first floor and upon investigation found the basement in the vicinity of the electric fuse box on fire. All lights went out within a few minutes and telephone service was cut off. A club member drove into the city and called the fire department, which call was recorded at 1:10 A.M.

Several fire companies responded, the first reaching the scene within five minutes. Five hose streams were used from pumpers taking water from a lake near by. The efforts of the firemen were directed on the first floor and basement until the floor fell through. At 3:00 A.M. additional forces were summoned and the fire department concentrated on saving the wings of the building. The fire was confined to the central portion of the building with a loss estimated in the vicinity of $150,000, representing approximately 70% of the insurable value of the property. Had the alarm been promptly given the fire might have been confined to the basement. (H-25978)

Delayed Alarm and Defective Construction.

BALTIMORE COUNTRY CLUB, ROLAND PARK, MD., OCT. 4, 1930. The building involved in this fire was a 3-story frame structure with a wooden shingle roof. There were large unprotected floor openings, and blind spaces were extensive throughout the several gables of the roof. City fire protection was available and the water supply was ample.

The fire had been burning for some time on the wooden shingle roof when discovered. It is thought to have started from sparks from a chimney, as open fireplaces were in use at the time. Employees attempted to fight the fire with hose streams from a standpipe but, although they claim to have

International.

Wooden shingle roofs, ignited by sparks, are one of the most frequent causes of country club fires. This picture shows the burning of the Baltimore Country Club at Roland Park, Md., October 4, 1930.

notified the fire department by telephone, the first alarm was given by an outsider who saw the flames and notified the engine company located two blocks away at 12:56 P.M.

When the first fire company arrived they found the fire spreading through the blind attic and immediately transmitted an alarm at 12:59 P.M. which was followed by an additional alarm at 1:09 P.M. The fire spread with great rapidity through the open areas in the gable roofs and, due to the lack of fire-stops, spread downward in the side walls and into the suspended ceilings of the second floor. The fire department had considerable difficulty in following the fire through the various blind spaces and only efficient work on their part prevented its spread to the first floor and basement. The roof was totally destroyed and side walls and interior partitions on the second floor were badly burned. (H-30192)

Defective Construction.

CEDARHURST COUNTRY CLUB, NEAR WYCLIFFE, OHIO, JAN. 10, 1926. Fire started in the attic of the two-story frame club house at 4:30 P.M. and is thought to have been due to a defective chimney which had no flue lining. The fire spread rapidly through concealed spaces and extinguishers and standpipe hose were of little value. The fire department arrived on the scene

Ruins of the Lakewood, N. J., Country Club. The fire started in a kitchen wing and slowly spread through the entire building. With no water available the fire department could do nothing to stop the progress of the flames. Had adequate fire fighting facilities been available at the start, the fire could have been extinguished with small loss.

at 5:00 P.M. and succeeded in saving the building from total destruction although the entire roof, attic and two-thirds of the second floor were destroyed. Zero weather hampered the firemen. The loss was $61,487, which represented about 54% of the sound value of the building and contents. (H-23043)

GREENWICH COUNTRY CLUB, GREENWICH, CT., JAN. 11, 1929. This was a large frame club house with a kitchen located in a one-story frame wing. From the hood over the kitchen range a metal vent pipe led to the outside, passing upward along the outside wall of the building and venting above the roof. The pipe was only about 2-inches from the wooden wall.

At about 11:30 A.M. grease which had collected on the inside of the vent ignited. The first evidence of fire was smoke appearing in rooms on the second floor and employees found that the wall of the building at about the third floor level was in flames. Attempts were made to extinguish the fire with chemicals from near-by windows, but the fire had entered the spaces between the studding through cracks in the shingled side walls and it quickly communicated to the wooden shingle roof, where it spread rapidly.

The volunteer fire department of the town was called and extinguished the fire by use of four streams provided by pumpers. The roof was burned off and about 30% of the third floor was destroyed. The loss was $85,100. (H-28309)

Defective Construction and Inadequate Water Supplies.

EAST LAKE COUNTRY CLUB, EAST LAKE, GA., MARCH 22, 1914. This fire occurred at 10:45 P.M., prior to which the odor of smoke had been noticeable for some time. After considerable search the fire was located under the

floor of the porch near the chimney. The grille room was under the porch and it contained a fireplace. The floor beams of the porch rested on the brick work of the fireplace and it is apparent that they became ignited. Hollow spaces between the porch beams facilitated the spread of the fire. Only small 1-quart fire extinguishers were available and although the Atlanta fire department was summoned, a six mile run coupled with meagre water supplies made effective fire fighting impossible. The loss was estimated at $50,000. (H-37016)

COUNTRY CLUB OF DETROIT, GROSSE POINT FARMS, MICH., OCT. 18, 1925. This fire demonstrates again that too much confidence must not be placed in so-called "fireproof" construction. Unprotected steel construction, joisted roof, wooden interior trim and combustible furnishings were prominent factors in the large loss occasioned by this fire. The building involved had walls of brick and stucco finish; reinforced concrete frame and floors; joisted roof on exposed steel trusses; tile partitions; open stairways and wooden interior trim. Public hydrants were available, and first aid extinguishers and a standpipe system were provided in the building. A watchman was on duty during the night.

The fire was discovered in the early hours of the morning by the watchman, who aroused other employees sleeping in the building. The fire started in the roof space in the vicinity of a dumb waiter shaft and traveled rapidly into the large wooden roof space over the otherwise fire-resistive lounge and ballroom section at about the center of the building. The fire department was summoned and responded promptly but found the water pressure deficient. It was more than forty minutes before sufficient water was available to effectively check the progress of the fire.

Meanwhile the heat affected the unprotected steel members supporting the wooden ballroom roof and they buckled, permitting the heavy slate roof to collapse and crash through the fire-resistive floor, taking along a portion of the adjoining section, which suffered more from the collapse than from actual fire. The loss on the building was placed at $293,037 or about 93% of the insurance carried, and the loss to contents was $42,589 or about 57% of its insured value.

In this fire an otherwise fire-resistive building was about as seriously damaged as one of inferior construction, simply because it had a wooden roof (under the slate) on unprotected steel supports. (H-23229)

EAST LAKE COUNTRY CLUB, EAST LAKE, GA., NOV. 22, 1925. Following the destruction of the former club house in 1914 a new building was erected, presumably of "fireproof" construction. Fire-resistive features were included but the building had a wooden roof (under the tile exterior), roof space not cut off from floors below, numerous unprotected floor openings, and stairs of ordinary wood joisted construction. A large amount of wood trim was used on the first floor.

The East Lake Country Club, near Atlanta, Ga., burned in 1914. It was rebuilt as a "fireproof" structure—with wooden stairs, trim and roof, highly combustible furnishings, no barriers to the spread of fire, and no adequate fire protection. These pictures show the results of the second fire, November 22, 1925. The loss to the structure was estimated at 85% of its value.

The fire was discovered between 3 and 4 A.M. The cause is not definitely known but is thought to have been due to the careless tossing of a lighted cigarette behind a radiator on the landing of the main staircase. This stairway, constructed of wood, was on fire throughout its entire length when the fire was discovered, and the spread of the fire to other portions of the building and combustible roof structure was rapid.

Calls were sent to near-by fire departments, and pending their arrival an attempt was made to control the fire with hand chemical extinguishers but the fire had reached such a stage as to render first aid equipment value-

less. The Atlanta fire department connected to a hydrant on a 4-inch dead-end main and laid 1100 feet of hose to the building. Water was not available in sufficient quantity, however, to produce even a fair stream. The Decatur fire department proceeded to a lake near by, and after experiencing some difficulty in finding a suitable place for their pumper to take suction, were able to supply one good stream. The fire had gained such headway by the time this stream was in service that protection was of little value and soon the entire building except the basement was involved. The loss was $154,168.

This fire, resulting as it did in an 85% loss to building and contents, illustrates again that little is to be gained in an attempt to provide safe construction in a building of this type unless all floor openings are properly protected and the combustible roof structure is properly cut off from floors below by a fire-resistive floor slab immediately under the roof. These features of construction should be given particular consideration in buildings where there is a large amount of wood trim, stairs of combustible material and floors of wood wearing surface, as was the case in this particular structure. (H-22832)

Remote from Fire Protection.

THE ELKS COUNTRY CLUB, COLUMBUS, OHIO, NOV. 2, 1930. This was a 2½-story frame club house with wooden shingle roof. It was located beyond the city limits half a mile from the nearest public fire hydrant and four miles from a fire station. Three 2½-gallon soda-acid extinguishers and a 35-gallon soda-acid wheeled extinguisher were provided on the property.

The evening of the fire the club manager banked the fire under the boiler at 8 P.M. and then retired. At 9 P.M. he was awakened by smoke in his room. He called the grounds keeper living near by, over a private telephone, and the latter immediately notified the Columbus fire department. The manager made his escape by way of the porch roof, procured the wheeled extinguisher and with the help of the grounds keeper fought the fire until the arrival of the fire department about eight minutes later.

The fire department immediately sent for additional equipment in order to get hose enough to reach from the nearest hydrant, meanwhile fighting the fire with chemical and booster streams from tanks on the apparatus. Additional fire fighting equipment eventually arrived and two pumpers pumping in relays from one to the other supplied two hose streams under fair pressure to fight the fire. The fire was beyond control by this time, resulting in a total loss to the building and contents estimated at $155,000. (H-30438)

First Aid Appliances.

THE DUNES CLUB, NARRAGANSETT PIER, R. I., AUG. 10, 1930. A very hot fire was made in a small coal-fired hot water heater. The drafts were opened wide and probably forgotten, with the result that an intense fire ensued which overheated the brick chimney to which the heater was con-

Keystone.

The fire at the Tedesco Country Club, Marblehead, Mass., on March 16, 1932, lighted the country for miles around in the early hours of the morning. Possibly due to the spontaneous ignition of painters' material, the fire spread rapidly through this large area wooden building and burst through the windows before it was discovered. Extreme cold hampered the firemen, and water from hose lines froze almost as soon as it struck the building.

nected. The heat set fire to roof timbers in contact with the chimney. The fire was discovered at 9:30 P.M. by the watchman, who summoned other employees. A small garden hose stream and 2½-gallon soda-acid extinguishers were used and the fire extinguished with a loss estimated at $40 before sufficient fire developed to operate the sprinklers. Damage consisted of heavy charring of roof members in contact with, and near the chimney. (S-56758)

WORCESTER COUNTRY CLUB, WORCESTER, MASS., AUG. 28, 1930. Fire occurred in a sleeping room on the second floor of the club house at 10 A.M. when a short circuit in the cord of an electric fan ignited waste paper in a basket. The fire was entirely extinguished by chemical extinguishers. Loss: $312. (S-55232)

CHARLES RIVER COUNTRY CLUB, NEWTON, MASS., APRIL 14, 1931. A kettle of fat on the stove boiled over and ignited. The fire and heat were carried into the hood over the stove which was vented to the outside. The building wall on the outside above this vent was slightly damaged and the accumulation of grease in the vent burned freely. The fire was extinguished by use of four chemical extinguishers before the automatic sprinklers opened.

The sprinklers did not operate due to the fact that most of the heat was vented to the outside of the building. The loss was $40. (S-59372)

BELLEMEADE COUNTRY CLUB, NASHVILLE, TENN., MARCH 11, 1932. This fire was caused by sparks from a chimney igniting the wooden shingle roof. The fire was first observed by an employee in the yard, who notified other employees. By use of three fire extinguishers the fire was practically extinguished before the arrival of the firemen, who used a chemical line to complete the job. The prompt use of first aid equipment extinguished the fire before there was sufficient heat to operate the automatic sprinklers. The loss was $50. (S-60166)

WINCHESTER COUNTRY CLUB, ARLINGTON, MASS., JUNE 8, 1932. A fire on the roof of the ballroom section of the club house was discovered by a policeman at 7:30 A.M. He notified employees and summoned the fire department. Employees took a line of ¾-inch garden hose through a window on to the roof and used several 2½-gallon soda-acid extinguishers with the result that the fire was practically extinguished when the fire department arrived. The cause of the fire was sparks from a chimney near by which ignited the wooden shingles on the roof. The loss was $200. (S-61088)

Loss of Life by Fire 1930-1933.

Since October 1930 each issue of the QUARTERLY has contained a summary of all reports of fires involving loss of life which have been received by the N.F.P.A. Department of Fire Record during the previous quarter. The reports received include those contributed by interested N.F.P.A. members. It is probable that the number of these loss of life fires reported to the N.F.P.A. represents not much more than 10 per cent of the fire deaths, which have been estimated at ten thousand lives annually for the United States and Canada, including all deaths for which fire may have been indirectly responsible as well as the direct fire casualties which are reported by the U. S. Census Bureau under the headings of "Burns" and "Conflagrations." The N.F.P.A. records, while representing only a fraction of the fires, cover a sufficiently broad base of experience to permit drawing conclusions as to the conditions under which loss of life by fire has occurred, and to show how such casualties may be avoided by proper measures of fire prevention and fire protection.

The quarterly summaries have now been published for a sufficient length of time to make a cumulative record desirable and the thirteen reports have accordingly been incorporated in the accompanying tables which cover the period from the middle of 1930 through the third quarter of 1933. These tables record 1910 fires in which a total of 3594 lives have been lost.

Table 1 shows the distribution of fatalities between men, women and children, also the division in classification between fires in residential build-

ings, other buildings, and fires outside buildings. There is also included a total of 64 deaths in response to fire alarms. These are for the most part fire apparatus accidents which, while classified as motor vehicle accidents for U. S. Census purposes, seem properly included in the list of fire casualties, as they would not have occurred except for fire. It is noted that the major loss of life has occurred in dwellings. The next greatest classification occurs in fires outside of buildings, which includes bonfires, forest and brush fires, mine, automobile, airplane and other fires that have occurred outside of buildings.

Table 2 gives the detailed occupancy analysis. It is interesting to note that the largest loss of life has occurred in residence properties, including dwellings, apartments, etc. The heavy loss of life in this class is in large measure due to the combustible construction so largely employed in the buildings used for residence purposes, to the lack of fire protection, and the fact that the majority of these fires occur while the occupants are asleep and are not warned of the fire until too late to make their escape from the burning structure.

Despite the greater fire hazard of manufacturing occupancies, it is interesting to note that a larger loss of life has occurred in school and institution fires. This may be explained by the generally inferior fire protection found in school and institution property as compared with the better grade of fire protection, including automatic sprinklers, generally found in the larger manufacturing properties.

In the fires outside of buildings, those occurring in mining property take the greatest toll. These casualties for U. S. Census purposes would presumably be largely listed as mine accidents, but as the casualties included here were all due to fire or to fire explosion, it seems proper to so list them for N.F.P.A. purposes. Airplane fires and automobile fires take the next largest toll. Here again the casualties may ordinarily be considered as airplane or automobile accidents, but only those cases have been included in the present records where

Table 1. Age and Sex of Victims by Occupancy Classification.

Age and Sex of Victims			OCCUPANCY CLASSIFICATION									
			Dwellings Apts., etc.		Buildings other than Dwellings		Outside of Buildings		Response to Alarms		No Data*
	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	No.	Per Cent	
Men	2027	56.8	507	29.2	464	74.8	984	84.9	62	97.0	10
Women	632	17.7	479	27.5	85	13.7	67	5.7	1	1.5	—
Children	910	24.8	738	42.4	66	10.7	105	9.1	1	1.5	—
No Data	25	.7	16	.9	5	.8	4	.3	0	0	—
Total	3594	100.0	1740	100.0	620	100.0	1160	100.0	64	100.0	10
Percentage distribution of casualties between various classifications.			48.4		17.3		32.2		1.8		.3

*Includes cases where data are insufficient to show occupancy, class of building, or whether casualty occurred in or outside building.

Table No. 2. Class of Fire.

	No. Fires	Men	Women	Children	No Data	Total
Fires in Buildings:						
Airports and hangars	6	8	0	0	0	8
Apartments, hotels, lodgings, tenements, etc.	154	150	69	66	7	292
Barns and stables	13	7	1	6	0	14
Buildings under construction	4	13	0	0	0	13
Churches	7	5	1	4	0	10
Dwellings—Rural	515	197	217	474	9	897
Dwellings—Urban	412	160	193	198	0	551
Fireworks and munitions plants	15	37	1	3	0	41
Gas works	3	17	0	0	0	17
Garages and filling stations	25	32	0	1	0	33
Grain elevators	7	15	0	0	0	15
Institutions, schools, etc.	34	89	51	2	4	146
Manufacturing occupancies	79	111	13	6	1	131
Mercantile occupancies	50	62	4	1	0	67
Motion picture theatres	4	6	0	0	0	6
Oil refineries	9	28	1	1	0	30
Other known buildings	49	34	13	42	0	89
Fires Outside of Buildings:						
Airplanes	113	208	17	6	0	231
Automobiles	133	148	42	23	4	217
Automobiles—Gasoline tank trucks	7	11	0	2	0	13
Forest or brush fires	18	29	0	4	0	33
Mining property	31	375	0	0	0	375
Oil or gas wells	12	39	0	4	0	43
Out-of-door fires (bonfires, etc.)	99	42	6	61	0	109
Railroad accidents	9	21	0	1	0	22
Ships and boats	35	45	2	4	0	51
Ships—Tankers and barges	7	66	0	0	0	66
Response to alarms	52	62	1	1	0	64
No data	8	10	0	0	0	10
Total	1910	2027	632	910	25	3594

it is clearly indicated that fire was a contributing cause of the death. In the case of an airplane crash, for example, the deaths have been considered fire casualties only where it appears that the occupants of the plane were still alive and might have lived, except for the fire which followed the crash. A similar policy has been followed in the classification of automobile fires.

Table No. 3 gives the causes of loss of life. As in the preceding summaries, the classification has been made so as to show the reason for the loss of life rather than the cause of the fire.

The table shows that 892 persons lost their lives when trapped in burning buildings, the largest number listed under any single item. Deaths are listed in this classification wherever it appears that the victims were trapped in burning buildings, due to the lack of proper exits, etc., irrespective of the initial cause of the fire.

Table No. 3. Causes of Loss of Life.

	Men	Women	Children	No Data	Total
Airplane fires	208	17	6	0	231
Airplane, crashed on house	7	2	4	0	13
Automobile fires	147	42	23	4	216
Children alone in house	0	0	43	0	43
Children and matches	0	1	83	0	84
Cleaning with gasoline	9	33	2	0	44
Clothing ignited:					
Bonfire, campfire, rubbish	5	2	23	0	30
Candle or torch	3	2	1	0	6
Electrical appliances	1	3	4	0	8
Fireplace	4	10	12	0	26
Furnaces or stoves	10	53	24	0	87
Gas heater	3	4	5	0	12
Matches	0	6	1	0	7
Oil stove, lamp, or heater	7	16	10	0	33
Miscellaneous	10	3	5	0	18
Escaping from fire—drowned	4	0	3	0	7
Escaping from fire—jumped or fell	12	3	2	0	17
Explosion:					
Blasting or gun powder	10	1	6	0	17
Carbide or acetylene tank	3	0	1	0	4
Dust	7	0	0	0	7
Fireworks or munitions plant	12	1	4	0	17
Gas appliances	6	5	3	0	14
Gas well	6	0	0	0	6
Gas works	14	0	0	0	14
Gasoline lamps	0	0	3	0	3
Gasoline stove	6	7	15	6	34
Gasoline vapor	9	3	2	0	14
Gasoline vapor in boat	11	0	1	0	12
Illicit still	12	4	2	0	18
Illuminating gas	26	6	2	0	34
Incendiary origin	7	12	3	0	22
Mine	368	0	0	0	368
Oil field	22	0	0	0	22
Oil stove or lamp	13	21	17	0	51
Oil refinery	38	1	1	0	40
Powder mill	13	0	0	0	13
Tank steamer or barge	66	0	0	0	66
Miscellaneous	56	11	13	0	80
Unknown	5	0	0	0	5
Fire fighting	106	1	0	0	107
Fireworks	6	1	10	0	17
Flash from burning pyroxylin material	6	6	2	1	15
Forest or brush fire	18	0	4	0	22
Gasoline tank truck accidents	8	0	2	0	10
Gasoline used to start fire	12	16	25	0	53
Ignition of flammable liquids or vapors	85	20	33	0	138

Table continued on next page

Table 3. Causes of Loss of Life (Continued).

	Men	Women	Children	No Data	Total
Illuminating gas ignited	9	3	2	0	14
Kerosene used to start fire	34	47	58	0	139
Motion picture film ignited	4	3	0	0	7
Overcome by smoke—suffocation	70	40	38	0	148
Overexertion or excitement	16	4	0	0	20
Railroad accidents	11	0	0	0	11
Re-entering burning buildings	22	19	6	0	47
Response to alarms	59	5	1	0	65
Shock or after effects of fire	10	17	0	0	27
Smoking	39	12	0	0	51
Trapped in burning buildings	325	159	394	14	892
Trapped while starting incendiary fire	6	0	0	0	6
Miscellaneous known causes	23	0	1	0	24
Unknown	18	10	10	0	38
Total	2027	632	910	25	3594

One hundred and thirteen airplane fires were responsible for 231 fatalities. In a large number of these fires the victims were injured in a crash and were trapped by fire resulting from the crash. Had it not been for fire, these injured persons might have been saved. Deaths obviously due to crash injuries rather than to fire have not been included in this tabulation.

Automobile fires were responsible for 216 deaths. The greatest cause of fatal automobile fires was the trapping of occupants in a wrecked or overturned machine following an accident or collision. As was the case with airplanes, most of these fires were due to ignition of gasoline released by the accident. In many cases ignition was due to careless smokers. Another cause which was responsible for several automobile fires was the carrying of additional fuel in open containers in the machine. This additional gasoline was also ignited by cigarettes or matches.

Children playing with matches caused eighty-four deaths. One woman listed under this classification was a mother who was fatally burned attempting to save her child from a fire he started while playing with matches. A large proportion of the victims of these fires were very small children and some were babies, who were burned in fires started by small brothers or sisters. Attention should also be called to the large number of children who were burned to death while left alone even for a short time. Often the reports stated that in a very short time the fire gained such headway that when discovered it was impossible to enter the building to save the children.

Explosions are shown to have been a major cause of loss of life. It is probable that some of the fires here listed as "explosion" were not true explosions, but were fires which spread so rapidly as to appear to be explosions. The predominance of men as explosion victims is explained by the fact that

many of these accidents occurred in manufacturing plants, mines, and other properties where most of the employees are men.

Outstanding among the causes of fatal dwelling fires is the use of flammable liquids. Fifty-three persons were killed as a result of using gasoline to start fires in stoves. Some of these victims believed that they were using kerosene, but others were ignorant or foolish enough to use gasoline deliberately. Kerosene used in a similar manner was responsible for 139 deaths. In some instances live coals remained in the stove, and vaporized kerosene flashed or exploded. The use of flammable liquids for home dry cleaning was responsible for 44 deaths, mostly women, and again emphasizes the seriousness of this hazard. Use of flammable liquids for other purposes both in and out of dwelling properties caused 138 additional deaths.

Another outstanding cause of loss of life is listed as "Overcome by Smoke—Suffocation." One hundred and forty-eight persons lost their lives in this manner. In most instances the victims were overcome while asleep. Heat rising from a fire below often caused the death of victims who were not touched by fire.

Total Annual Loss of Life by Fire.

The average loss of life reported by the U. S. Census Bureau as due to conflagrations and burns (excluding molten metal and scalds), is 6338, for the death registration area of the United States. Computations based on this figure place the total for the continental United States at 7125 (1921-29 average). As indicated in the preceding discussion there are many deaths, included in the present tables, which would not have occurred had there been no fire, but which would ordinarily be recorded in death certificates under classifications other than "conflagration" or "burns." In the accompanying tables there are 1203 deaths out of the total of 3594 which may have been recorded in mortality statistics under other than fire classifications. This may be taken as indicating that the total number of deaths for which fire is directly or indirectly responsible may be about fifty per cent greater than the number reported under the census classifications of "burns" and "conflagrations." Applying this percentage to the 1921-29 average of 7125 deaths, gives a total of 10,687, which indicates that the generally accepted estimate of ten thousand lives lost by fire annually is conservative.

Fires in Which There Was Loss of Life.

Third Quarter, 1933.

Since the publication of the July QUARTERLY, the N.F.P.A. Department of Fire Record has received from various sources 149 reports of fires in which there has been loss of life. A total of 245 lives were lost in these fires.

There were two disasters in which more than five lives were lost, occurring during the period covered by this record. The first of these was the result of an explosion in an oil refinery at Smackover, Ark., on July 14, 1933, which was responsible for the loss of seven lives. The cause of this explosion was not determined. The second disaster occurred on September 10, when a mine explosion at New Kensington, Pa., also caused seven deaths. Two blasts occurred about twenty minutes apart and were said to have been due to the ignition of mine gas.

Loss of Life Fires, July-September, 1933.*

This is a typical rather than a complete record, presented to show the conditions under which loss of life occurs, that they may be known and guarded against. The total loss of life by fire in the United States is estimated at 10,000 annually.

Class of Fire	No. Fires	Men	Women	Children	No Data	Total
Airplane fires	6	11	1	1	0	13
Apartments, hotels, lodgings, tenements, etc.	7	4	2	3	3	12
Automobile fires	18	21	6	2	0	29
Barns and stables	2	1	1	0	0	2
Dwellings—Rural	47	11	25	41	0	77
Dwellings—Urban	22	6	11	9	0	26
Gasoline tank truck accidents	1	1	0	0	0	1
Garages	2	3	0	0	0	3
Industrial occupancies	4	4	2	0	0	6
Institutions, schools, etc.	2	2	0	0	0	2
Mercantile occupancies	5	9	1	0	0	10
Mining property	2	8	0	0	0	8
Oil refineries	3	10	0	0	0	10
Other buildings	10	12	2	4	0	18
Outside of buildings	11	1	2	9	0	12
Powder plants	1	3	0	1	0	4
Railroad property or accidents	1	2	0	0	0	2
Response to alarms	2	2	0	0	0	2
Ships and boats	1	0	0	3	0	3
Tank ships or barges	2	5	0	0	0	5
Total	149	116	53	73	3	245

*This table is made up from those reports received by the Department of Fire Record between July 1 and September 30, 1933. A few of the fires included herein occurred prior to July 1, but were not reported until subsequent to that date.

Causes of Loss of Life, July-September, 1933.

Fatalities classified according to the immediate cause of the loss of life rather than according to the cause of the fire.

Cause	Men	Women	Children	No Data	Total
Airplane fires	11	1	1	0	13
Automobile fires	20	6	2	0	28
Children alone in house	0	0	11	0	11
Children and matches	0	0	4	0	4
Cleaning with gasoline	3	4	0	0	7
Clothing ignited:					
Backfire of boiler	1	0	0	0	1
Bonfire	0	0	4	0	4
Gas heater	0	1	0	0	1
Match tossed from window	0	0	1	0	1
Match used for light	0	1	0	0	1
Motion picture film	0	1	0	0	1
Oil stove	0	2	0	0	2
Stove	0	0	1	0	1
Escaping from fire—drowned	0	0	3	0	3
Explosion or flash fire:					
Fireworks factory	3	0	1	0	4
Gas lamp or heater	3	1	0	0	4
Gasoline cornpopper	0	1	0	0	1
Gasoline locomotive	2	0	0	0	2
Gasoline stove or heater	2	2	4	0	8
Gasoline tank	0	0	1	0	1
Illicit still	0	1	0	0	1
Kerosene can on stove	0	1	0	0	1
Mine	8	0	0	0	8
Oil lamp or stove	1	4	4	0	9
Oil refinery	10	0	0	0	10
Pyroxylin	2	2	0	0	4
Tank ship or barge	4	0	0	0	4
Fire fighting	12	0	0	0	12
Fireworks	1	1	3	0	5
Forest fire	1	0	0	0	1
Gasoline tank truck accidents	1	0	0	0	1
Gasoline used to start fire	0	4	2	0	6
Hit by falling chimney	1	0	0	0	1
Ignition of flammable liquids or vapors	7	2	2	0	11
Kerosene used to start fire	1	4	3	0	8
Overcome by smoke—suffocation	2	1	0	0	3
Overexertion or excitement	2	0	0	0	2
Re-entering burning buildings	1	3	0	0	4
Response to alarms	2	0	0	0	2
Smoking	3	2	0	0	5
Trapped in burning building	12	8	26	3	49
Total	116	53	73	3	245

Typical Loss of Life Fires.

Automobile Fires.

L-2133. MILLERSVILLE, ILL., JULY 26, 1933. An automobile bus carrying thirty members of the Illinois National Guard caught fire from an undetermined cause just back of the driver's seat while traveling along the road at a forty-mile per hour speed. Before the bus could be brought to a stop the fire had enveloped the interior, fatally burning two of the guardsmen and causing painful injuries to twenty others. Both the front and rear exits as well as windows were used by survivors as means of escape.

L-2134. NEAR HAYWARD, CAL., JULY 27, 1933. Two baby girls lost their lives and their father was severely burned in an attempt to save them, when gasoline carried in a can on the back seat of an automobile was ignited. The fire started when the father lighted a match. Flames quickly enveloped the rear seat of the car where the two children were seated. The father pulled them both from the car, but not before they had suffered fatal burns. The mother, with an infant in arms, escaped safely from the front seat.

L-2135. NEAR OWENSBORO, KY., JULY 29, 1933. When their automobile ran into a ditch and overturned, the driver and two companions were thrown out. The driver picked himself up, took a cigarette from his pocket and proceeded to the wrecked car to get a match from his coat pocket. When he lighted the match gasoline which had spilled about the car burst into flames and he was trapped and burned beyond recognition.

Children and Bonfires.

L-2143. HOLYOKE, MASS., JULY 9, 1933. A six-year-old girl was fatally burned when her clothing caught fire from a bonfire started in a vacant lot by boys. Before neighbors could reach her, the little girl was so badly burned that she died in the hospital that night.

L-2144. LAWRENCE, MASS., AUGUST 15, 1933. While playing at a bonfire near her home after other children had gone home to supper a four-year-old girl was fatally burned. A neighbor saw the girl's plight and went to her aid. He was seriously burned on his hands extinguishing her burning clothing.

L-2145. HAGERSTOWN, MD., SEPTEMBER 10, 1933. A five-year-old girl died in a hospital from burns received when her clothing caught fire from a bonfire. The child started the fire in a pile of rubbish near her home.

Children Alone in House.

L-2138. NEW YORK, N. Y., JULY 3, 1933. A three-year-old boy was fatally burned when left alone in the apartment where he lived. The fire, discovered by neighbors, occurred during the evening at a time when both parents were out at work.

L-2139. NEAR GREAT FALLS, MONT., AUG. 11, 1933. Two children were burned to death when a fire trapped them on the first floor of their farm home. A brother, eleven years old, was injured attempting to rescue the victims. The father was at work and the mother was away on a visit when the fire occurred.

L-2140. BUFFALO, N. Y., AUG. 12, 1933. One child was fatally burned and another lost his life from suffocation when fire broke out while they were alone in their apartment. The mother left the house shortly after midnight while the children were asleep and forgot to detach the electric iron. A few minutes later passing motorists discovered the fire, but were prevented from rescuing the children by the dense smoke.

L-2141. NEAR GREENSHIELDS, ALTA., AUG. 26, 1933. Two baby girls, the oldest three years of age, were burned to death when fire razed their farm home. Their parents, milking in the barn when they saw the flames, were unable to reach the children, although a door to the house was open. A faulty chimney was blamed for the tragedy. Flames were coming through the roof when the fire was first noticed.

L-2142. HUNTSVILLE, ONT., SEPT. 13, 1933. A baby girl was burned to death in a fire which destroyed the summer home of her parents. The child had been left in the care of her grandmother and an aunt in the absence of the parents. These women were at dinner in the dining hall of the summer resort where the cottage was located when the fire was discovered. Before they could reach the scene the fire was beyond control and nothing could be done to save the child.

Escaping from Fire.

L-2154. WARRENSBURG, N. Y., SEPTEMBER 9, 1933. Three boys were drowned when they jumped from a burning rowboat. The boys had been lighting "cattails," which were first dipped into a bucket of gasoline in the boat. The fire started when the bucket was overturned. One other boy managed to swim ashore.

Kerosene Used to Start Fire.

L-2150. ST. HYACINTHE, P. Q., SEPTEMBER 7, 1933. A six-year-old girl was fatally burned as a result of using kerosene to start a fire in the kitchen stove. The mother prepared to light the fire, pouring a small amount of kerosene on the paper and wood, and then left the room. The child, intending to help her mother, applied a match to the fuel and a flash occurred which immediately enveloped her in flames.

L-2151. GILMER, TEX., SEPTEMBER 12, 1933. A mother and two small children were burned to death in a fire which started when one of the parents used kerosene to start a fire. The mother died while trying to save her children. The father was seriously burned.

Gasoline Used to Start Fire.

L-2147. ALLEGHANY STATE PARK, N. Y., AUGUST 22, 1933. Four girls were fatally burned when the mother of two of the victims used gasoline to start a fire in the stove of a one-room cabin which they occupied. The gasoline was used after a previous unsuccessful attempt to kindle a fire. It is probable that the fuel was ignited by a smouldering ember remaining in the stove. The mother escaped with burns on her face and arms, but flames cut off the single exit before the girls could make their escape, and when help arrived the cabin was a mass of flames. The four bodies were found huddled together near the cots.

Gas Explosion.

L-2146. CHARDON, NEB., JULY 24, 1933. A woman died in a hospital as a result of burns received when she attempted to light a gas water heater. The victim had lighted the basement heater and later returned to find it out. She struck a match to relight it and the gas exploded.

Ignition of Flammable Liquids or Vapors.

L-2148. MILWAUKEE, WIS., AUGUST 15, 1933. A man was fatally burned when his clothing caught fire as the result of an explosion of the gasoline tank of an old automobile, which he was dismantling in an automobile salvage plant. The explosion occurred when a spark from an acetylene torch, which the victim was using, ignited vapors in the gasoline tank.

L-2149. OWEN SOUND, ONT., AUGUST 28, 1933. A young man was fatally burned in an explosion of gasoline fumes which occurred when a friend struck a match for light while the victim was attempting to repair a leaking gasoline line on his car. His friend received severe burns on his hands while trying to extinguish the victim's burning clothing.

Smoker Fell Asleep.

L-2152. NEWTON, MASS., JULY 6, 1933. A woman was fatally burned when she fell asleep on a divan while smoking a cigarette. Finding herself afire, she rushed to the piazza, where she collapsed. Neighbors ignored her screams for about twenty minutes, believing them to be the noise of children at play, before they saw the smoke and summoned assistance.

L-2153. SAN JOSE, CALIF., JULY 30, 1933. A man was fatally burned in a fire which started when his cigarette ignited his bed clothing when he fell asleep. Discovering the fire, he attempted to carry the blazing mattress and blankets into a bathroom to extinguish the flames without calling the fire department.